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# The Endocrinology of Personality, Leadership, and Economic Decision Making

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# The Endocrinology of Personality, Leadership, and Economic Decision Making

**by**

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**The Endocrinology of Personality, Leadership, and Economic Decision Making**

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Do endocrine systems influence personality and social behavior? Although animal research has identified several hormone-behavior relationships and the mechanisms that give rise to them, much less is known about hormones and social functioning in humans. This dissertation used three large data sets to investigate whether testosterone and cortisol were related to variation in personality constructs (Study 1), leadership behaviors (Study 2), and economic decision making (Studies 3 and 4). Study 1 revealed that basal testosterone was negatively associated with conscientiousness, basal cortisol was negatively associated with extraversion but positively associated with social dominance orientation, and the interaction between testosterone and cortisol was associated with the implicit power motive. Study 2 found that the testosterone-cortisol interaction predicted leadership behaviors, and Study 3 showed that basal testosterone as well as change in cortisol predicted economic decisions in the Hawk-Dove Game. Finally, Study 4 demonstrated that aggression predicted decisions to punish unfair monetary offers in the Ultimatum and Third Party Punishment Games. Aggression was also related to women's changes in testosterone from before to after the games. Taken together, these studies provide important evidence that testosterone and cortisol are related to personality, leadership, and social decision making. More broadly, this dissertation lays the empirical foundation for further inquiry on the complex biological systems that regulate personality and social behavior.

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# INTRODUCTION

Psychologists have long understood that research on the biological systems of social behavior is critical to our understanding of human social functioning. In his 1967 book entitled *The Biological Basis of Personality*, for example, Hans Eysenck reviewed the extant research on personality and physiology and called for continued research on the topic. Despite the importance that Eysenck placed on biology, modern day social and personality psychologists largely ignore the biological level of analysis, and instead, rely almost exclusively on behavioral measures as well as self-reports of cognition and affect to explain social phenomena. Indeed, the dominant perspective in personality psychology -- the trait approach – tends to focus on behavioral and questionnaire assessments for drawing conclusions about personality. Although this approach has certainly been useful, research that measures biological variables along with behavioral ones can potentially provide unique insights into the biological systems of personality and social behavior.

Social endocrinology is an emerging interdisciplinary field that seeks to understand the relationships among hormones, the environment, and social behavior in humans. Although some progress has been made in this field, there are only a few social and personality psychologists who study hormones. This is surprising given the relative ease with which some hormones can be measured through saliva (e.g., testosterone, cortisol, estrogen) and the vast animal literature demonstrating that variation in hormone levels can explain a variety of social behaviors, such as dominance (Wingfield, Hegner, Dufty, & Ball, 1990), aggression (Giammanco et al., 2005), and affiliation (Bartz & Hollander, 2006). Even in the field of social neuroscience, which studies the neural systems that regulate social behavior, researchers have generally ignored other relevant biological processes, such as endocrine systems, that should interact with neural systems to drive behavior. Thus, research that incorporates hormone measurement into behavioral studies can greatly contribute to both psychology and neuroscience.

The goal of this dissertation is to investigate whether two hormones in particular – testosterone and cortisol -- are associated with important facets of human personality and social behavior. I take a broad empirical approach, and seek to make discoveries that will motivate new directions for future research in social endocrinology. To accomplish this goal, I will investigate three broad research questions: (1) Are testosterone and cortisol related to personality traits and implicit motives? (2) Do testosterone and cortisol predict social behaviors, including leadership behavior and economic decisions in dyadic interactions? and (3) How does the predictive validity of hormones compare to the predictive validity of other personality measures (self-reported personality traits, implicit motives)? In the present chapter, I review the relevant literature on hormones and social behavior. Then, I provide a general overview of the four studies designed to answer these research questions.

## Literature Review: Hormones, Personality, and Social Behavior

### Testosterone and Dominance

The literature on hormones and social behavior indicates that testosterone (T) levels are associated with dominance – behaviors intended to gain or maintain high status (Mazur & Booth, 1998). Both naturally occurring and experimentally elevated levels of T are positively associated with social rank and dominant behaviors in a variety of species, including primates (lemurs, Cavigelli & Pereira, 2000; squirrel monkeys, Coe, Mendoza,

& Levine, 1979; sifakas, Kraus, Heistermann, & Keppeler, 1999; chimpanzees, Anestis, 2006; Muller & Wrangham, 2004; baboons, Sapolsky, 1991), as well as many other animals (e.g., birds, Collias, Barfield, & Tarvyd, 2002; fish, Oliveira, Almada, & Canario, 1996; lambs, Ruiz-de-la-Torre & Manteca, 1999). This relationship between T and dominance tends to emerge most strongly during periods of social instability. In his research in wild baboons for example, Sapolsky (1991) demonstrated that T predicted status-related behaviors when the status hierarchy was unstable (after the alpha male was crippled in fighting and social competition broke out). When the hierarchy was stable, however, T and behavior were unrelated. This basic pattern of results – that T predicts behavior most strongly during periods of social competition -- has been found in a number of other species (fish, Oliveira, Almada, & Canario, 1996; lambs, Ruiz-de-la-Torre & Manteca, 1999; birds, Wingfield, Hegner, Duffy, & Ball, 1990). In Ruiz-de-la-Torre & Manteca's (1991) study of lambs, for instance, pre-pubescent males injected with T showed increases in dominant behaviors only after they were placed in a group of unfamiliar lambs, but not when placed back in their original social group.

The association between higher T and dominance has also been extended to humans. For instance, people high in basal T tend to be more aggressive and more socially dominant than individuals low in basal T (Archer, 2006; Archer, Birring, & Wu, 1998; Cashdan, 1995; Grant & France, 2001; Josephs, Newman, Brown, & Beer, 2003; Josephs, Sellers, Newman, & Mehta, 2006; Mazur & Booth, 1998; Jones & Josephs, 2006; Newman, Sellers, & Josephs, 2005; Sellers, Mehl, & Josephs, in 2007; Tremblay et al., 1998). T also increases vigilance toward dominance cues, such as angry, threatening faces (van Honk et al., 1999, Wirth & Schultheiss, 2007), and decreases vigilance toward submissive cues, such as fearful faces (van Honk, Peper, & Schutter, 2005). Interestingly, these effects of T on attention seem to be strongest when dominance-submission cues are presented outside of conscious awareness (e.g., van Honk et al., 2005; Wirth & Schultheiss, 2007), suggesting that the relationship between T and dominant behaviors may be mediated, at least in part, by subconscious motivational and attentional processes.

The relationship between T and dominance has been further demonstrated through experimental studies in which social status is manipulated (Josephs et al., 2003, 2006; Newman et al., 2005). One widely employed animal model for manipulating status is to assign individuals to victory and defeat in competitive social interactions (Keeney et al., 2006; Kramer, Hiemke, & Fuchs, 1999; Overli, Harris, & Winberg, 1999). Consistent with these animal models, Josephs et al., (2006) randomly assigned humans to high and low status by rigging the outcome of a cognitive-based laboratory competition. The findings indicate that high T individuals function better in high status positions than in low status ones. Specifically, high T individuals paid more attention to status cues, became dysphoric, and performed poorly on complex cognitive tasks after defeat, but paid less attention to status cues, showed no evidence of dysphoria, and performed well on complex cognitive tasks after victory. This pattern of findings has been replicated using different status manipulations (Josephs et al., 2003; Study 2, Josephs et al., 2006; Newman et al., 2005). Taken together, this literature suggests that high T individuals are driven to rise in status; when they achieve high status, high T individuals experience pleasure and adaptive functioning (e.g., good cognitive performance), but when they fail to achieve high status, high T individuals experience dysphoria and maladaptive functioning (e.g., poor cognitive performance).

Across these same studies, low T individuals reacted very differently to changes in status. In some of the studies, low T individuals' reactions to high and low status were similar to control conditions (Josephs et al., 2003; Newman et al., 2005), suggesting that they do not have the same strong preference for high status that high T individuals have. But in other studies, low T individuals reacted more negatively to *high* status than to low status. Specifically, low T participants were hyper-vigilant to status cues, showed elevated cardiovascular arousal, and performed poorly on complex cognitive tasks in a high status position, but not in a low status position (Josephs et al., 2006). These latter findings suggest that low T individuals might actually prefer *low* status and actively avoid high status. As Josephs and colleagues (2006) argue, low T individuals "might shun high status positions…because they lack a strong power motive…, they lack a dominating, aggressive personality…, and they may not believe they have what it takes physically to maintain such positions….". Thus, when low T individuals are thrust into a high status position, they may experience arousal and maladaptive functioning out of a desire to return to a more comfortable and safer position of low status.

The bulk of the research examining T and dominance has been conducted in men. But a small, growing literature suggests that basal T may also tap into dominance in women. For example, women high in basal T tend to have aggressive, dominant personalities (Dabbs & Hargrove, 1997; Dabbs, Ruback, Frady, & Hopper, 1988), and tend to show cognitive impairment after their status is threatened (Josephs et al., 2003). Further, the few studies that examined the interaction between basal T and status using mixed-sex samples found no evidence for sex differences (Josephs et al., 2006), indicating that similar to high T men, high T women also react negatively to low status, but not to high status.

### *Basal versus Reciprocal Model of Testosterone and Dominance*

If testosterone is indeed related to dominance, then what causes what? Does testosterone cause dominance? Or do acts of dominance lead to rises in testosterone? There seems to be evidence for both types of effects, which have led to two different theoretical models to account for the testosterone-dominance relationships: the basal model and the reciprocal model (Mazur & Booth, 1998).

*Basal Model*. According to the basal model, testosterone levels can be thought of as a trait, whereby individual differences in basal testosterone cause variation in dominant behaviors. In support of this model is evidence that basal T levels are temporally stable across five days (Sellers, Mehl, & Josephs, 2007), eight weeks (Dabbs, 1990), or even one year (Granger, Shirtcliff, Booth, Kivlighan, & Schwartz, 2004). There is also evidence from twin studies for a substantial heritable component to basal T levels (Harris, Vernon, & Boomsma, 1998). Finally, T levels measured at a single point in time are associated with chronic behavioral tendencies (e.g., Dabbs, Carr, Frady, & Riad, 1995; van Bokhoven et al., 2006). Taken together, these findings support the basal model and suggest that basal T can be thought of as individual difference variable that has a causal influence on social behaviors.

*Reciprocal Model*. According to the reciprocal model, dominant behaviors or situations cause testosterone levels to change, and these changes in testosterone then feed back to reinforce or discourage further acts of dominance. Research has also supported this model. For example, studies of real-world sports competitions and rigged laboratory competitions have shown that winners increase in T relative to losers for a few hours following a competition (Elias, 1981; Gladue et al., 1989; Mazur, Booth, & Dabbs, 1992; Mazur and Lamb, 1980; McCaul, Glaude, & Joppa, 1992), although additional studies suggest that the effect of wins and losses on T changes depend on personality dispositions (e.g., implicit power motive, Schultheiss et al., 2005). Studies also provide support for the second half of the model -- that these temporary changes in testosterone after competing influence subsequent dominant behaviors (e.g., Mehta & Josephs, 2006, Trainor, Bird, & Marler, 2004). For example, Mehta and Josephs (2006) experimentally varied the outcome a laboratory competition and measured changes in testosterone from before to after the competition. After measuring testosterone change, they asked participants whether they wanted to compete again on the same task against the same opponent. The results showed that losers who rose in testosterone after the competition chose to compete again, whereas losers who dropped in testosterone chose to avoid a second competition. These findings, together with experimental research in animals (Trainor et al., 2004), suggest that short-term fluctuations in testosterone can influence subsequent dominant behaviors.

Overall then, there seems to be support for both trait and state effects of T on behavior. Basal T is a reasonably stable individual difference variable associated with a general tendency towards dominance, whereas short-term fluctuations in T tend to increase or decrease an individual's motivation for status, which further encourages or discourages acts of dominance (cf. Mehta, Jones, & Josephs, under review).

### *Dominance versus Aggression*

In many personality theories, including the most widely accepted five factor model (McCrae & Costa, 1997), aggression and dominance are thought to be independent non-overlapping traits. Indeed, research shows that aggression is strongly associated with Agreeableness (Tremblay & Ewart, 2005), whereas dominance is strongly associated with Extraversion (McCrae & Costa, 1989). Recently, some scholars have suggested that testosterone may be more closely associated with dominance motivation than with aggression (Mazur & Booth, 1998). In animals, dominance motivation is often expressed as aggression, but in humans, aggression may not necessarily be the best means to achieve high status. However, most of the research on testosterone and social behavior does not draw clear distinctions between aggression and dominance; in fact, in many instances the behaviors that are assessed can be considered both aggressive and dominant. Thus, more empirical evidence is needed to disentangle testosterone's relationship with these two conceptually distinct classes of social behavior.

## Testosterone and Sensation-Seeking

Most of the literature on testosterone has focused on its relationship to aggression and social dominance, but some studies have shown that testosterone is positively associated with sensation-seeking (Aluja & Torrubia, 2004; Coccaro et al., 2007a; Fink et al., 2006), defined as the tendency to seek out novel, complex, varied, complex, and intense sensations and experiences (cf. Fink et al., 2006). These findings have led some researchers to speculate that any relationship between testosterone and aggression may be mediated by variation in sensation-seeking (Fink et al., 2006). However, this hypothesis has not yet been empirically tested.

## Cortisol and Social Behavior

The steroid hormone cortisol, widely regarded as the stress hormone (Sapolsky, 1998), is released by the hypothalamic-pituitary-adrenal (HPA) axis in response to physical exertion (Mastorakos, Pavlatou, Diamanti-Kandarakis, & Chrousos, 2005) and psychological stress (Dickerson & Kemeny, 2004). Although most of the research on cortisol has focused on the dispositional and situational variables that cause acute changes in cortisol (e.g., Dickerson & Kemeny, 2004), some research has explored the relationship between cortisol and social functioning. Animal studies show that elevated cortisol during stress is associated with freezing behaviors (rats; Nunez et al., 1996; primates, Kalin et al 1998), a response style that is thought to be an extreme form of behavioral inhibition. Additional studies in humans demonstrate that elevated cortisol is associated with social avoidance and inhibition, including anxiety and defensiveness (Brown et al., 1996) as well as social inhibition and internalizing behaviors (Kagan et al., 1987; Smider et al., 2002). Low basal cortisol has also linked to more aggressive behaviors (Shoal et al., 2003; Virgin & Sapolsky, 1997). In one longitudinal study of 314 boys, low basal cortisol levels during preadolescence (age 10 to 12) predicted low harm avoidance, low self-control, and more aggressive behaviors five years later. Further analyses suggested that low self-control mediated the relationship between low cortisol and aggression. Overall, the research suggests that high cortisol is associated with anxiety and behavioral inhibition, whereas low cortisol is associated with low self-control and aggression.

**Cortisol-Testosterone Interactions and Social Behavior**

Studies of hormones and social behavior tend to examine independent hormone-behavior relationships, but there is also some evidence that testosterone and cortisol can interact with one another to influence social behaviors (Dabbs et al., 1991, Popma et al., 2007). One recent study of male adolescents (ages 12 to 14) found that the interaction between testosterone and cortisol predicted individual differences in overt aggression (Popma et al., 2007). Among individuals low in basal cortisol, testosterone was positively related to over overt aggression. But among individuals high in basal cortisol, testosterone and overt aggression were unrelated. The interaction between testosterone and cortisol was not a significant predictor of covert aggression. This study conceptually replicated a previous study of 17 to18 year-old male offenders (Dabbs et al., 1991), which also found that high testosterone coupled with low cortisol was predictive of aggressive behaviors.

Other research suggests that cortisol and testosterone were related under conditions of social subjugation (Mehta & Josephs, 2006). Individuals high in basal cortisol who lost in a one-on-one competition subsequently dropped in testosterone, whereas individuals low in basal cortisol who lost rose in testosterone. These changes in testosterone were, in turn, predictive of decisions to re-engage or withdraw from further competition. Together, these studies support the hypothesis that cortisol may be a social inhibitor, whereas testosterone may be associated with a drive for dominance.

## Overview of Samples and Studies

This dissertation presents four studies that build upon previous research to further investigate relationships between hormones, personality, and social behavior. Study 1 seeks to identify the personality traits and implicit motives that are associated with basal testosterone and cortisol levels. Study 2 examines whether hormones and self-reported personality traits are associated with social behaviors in leader-follower dyadic interactions. It also tests whether basal hormones can predict social behaviors above and beyond self-reports. Study 3 tests whether basal hormones, self-reported personality traits, and implicit motives predict economic decisions in an iterative Hawk-Dove Game. This study also compares the predictive validity of the three classes of individual differences variables (basal hormones, self-reports, and implicit motives). Finally, Study 4 examines whether basal testosterone and self-reported personality predict economic decisions in the Ultimatum and Third Party Punishment Games.

The studies make use of three large data sets to answer research questions of interest. Table 1 summarizes the each of the studies, including the samples used in each study and the major research questions.

*Table 1. Overview of Studies*

| **Study** | **Sample(s)** | **Primary Research Question(s)** |
|---|---|---|
| Study 1 | Leader-Follower Sample<br>Hawk-Dove Sample<br>Ultimatum/Third Party Punishment Sample | Are basal testosterone and cortisol related to personality traits and implicit motives? |
| Study 2 | Leader-Follower Sample | Do basal testosterone and cortisol predict leadership behaviors?<br><br>How does the predictive validity of hormones compare to the predictive validity of self-reported personality traits? |
| Study 3 | Hawk-Dove Sample | Do basal testosterone and cortisol predict competitive versus cooperative economic decisions?<br><br>How does the predictive validity of hormones compare to the predictive validity of self-reported personality traits and implicit motives? |
| Study 4 | Ultimatum/Third Party Punishment Sample | Does basal testosterone predict decisions to punish unfair economic offers?<br><br>How does the predictive validity of hormones compare to the predictive validity of self-reported personality traits? |

In the following sections, I broadly describe each of these samples and how they will be used.

**Leader-Follower Sample**

The leader-follower sample was collected in the Spring, Summer, and Fall of 2004. One hundred seventy-five undergraduate psychology students (85 men) participated in the study. Forty-nine participants were run individually, and the remaining 126 participants were run in same-sex dyads. All participants provided one saliva sample, which was analyzed for testosterone and cortisol levels. Participants also filled out a variety of self-reported personality questionnaires. The full sample of 175 participants will be used in Study 1 to test relationships between hormones and personality traits.

All participants completed the Wechsler Adult Intelligence Scale (WAIS-III) Block Design Task (Wechsler, 1997). Participants either completed the task individually or in leader-follower dyads. Of the 126 participants who were run in dyads, 100 participants (50 men) were videotaped as they interacted with one another on the WAIS block design task as leader and follower. After completion of the study, seven research assistants watched the videotapes and rated each participant's social behaviors. Data from these 100 participants will be used in Study 2 to test whether self-reported personality and hormone levels are related to social behaviors in leader-follower interactions.

**Hawk-Dove Sample**

The Hawk-Dove sample was collected in the Fall of 2005 and Spring of 2006. Ninety-eight undergraduate psychology students (42 men) participated in the study. Prior to coming to the lab, participants filled out a variety of personality questionnaires online. Participants also completed an online version of the Picture Story Exercise, in which participants wrote creative stories in response to picture cues. Three trained research assistants later used Winter's (1994) system to code the stories for implicit achievement, achievement, and power motives.

After completing the online exercises, participants reported to the lab in same-sex dyads. Participants provided an initial saliva sample and then played five rounds of the Hawk-Dove Game with one another. Then participants provided a second saliva sample and played five more rounds of the game. Finally, participants provided a third saliva sample and were paid in cash based on their decisions in the game. The saliva samples were later analyzed for testosterone and cortisol concentrations. Study 1 will use the data on hormones, self-reported personality, and implicit motives to investigate relationships between hormones and personality. Study 3 will additionally use the decision making data to examine whether hormones, self-reported personality, and implicit motives are associated with economic decisions.

**Ultimatum/Third Party Punishment Game Sample**

The Ultimatum/Third Party Punishment Game sample was collected in the Spring of 2007. One hundred fifteen participants (54 men), composed of both UT students as well as Austin community members, participated in the study. Prior to coming to the lab, participants filled out a variety of personality questionnaires online.

After completing the online exercises, participants reported to the lab individually or in groups of up to five people. Participants provided an initial saliva sample, and were photographed. Then participants played the Ultimatum Game in the role of responder, and the Third Party Punishment Game in the role of third party punisher. Participants played these games via a computer interface and were led to believe they were playing with other individuals in one-shot interactions. Finally, participants provided a second saliva sample and were paid in cash based on their decisions in the two games. The saliva samples were analyzed for testosterone concentrations only; although the samples will eventually be assayed for cortisol as well, cortisol data were unavailable at the time this document was completed. After the study, friends and family members of participants were emailed and were asked to rate the participant's personality. Study 1 will use the data on basal testosterone, self-reports, and informant reports to investigate relationships between testosterone and personality constructs. Study 4 will use these same measures as well as the economic decision making data to test whether hormones and personality predict economic decisions.

**Summary**

The four studies take a multi-trait, multi-method approach to personality assessment and include behavioral measures in order to rigorously investigate whether hormones are associated with personality and social behavior. Each study represents a novel approach to the study of personality and social behavior. For instance, very few empirical studies to date have tested whether individual differences in hormone levels are associated with social behaviors in leader-follower interactions or in economic decision making interactions. Studies 2, 3, and 4 seek to address these gaps in the literature. And even among those studies that have sought to understand the relationships between hormones and social behaviors (e.g., Archer, 2006), most of these studies have failed to compare the predictive validity of hormones to the predictive validity of other personality assessment tools, such as self-reports and implicit motives. This dissertation seeks to make these comparisons. Finally, most researchers of hormones examine the relationship between a single hormone and social behavior. However, both animal (Viau & Meaney,

1996) and newer human research (Mehta & Josephs, 2006; Mehta, Jones, & Josephs, under review; Popma et al., 2007) suggest that hormones interact with one another in complex ways. Therefore, in addition to testing independent hormone-personality and hormone-behavior relationships, Studies 1, 2, and 3 will also investigate whether testosterone and cortisol interact to predict personality and social behavior.

Taken together, this dissertation has the potential to uncover the relationships among hormones, personality, and social behaviors; to determine how hormones are related to other personality assessment tools; and to elucidate the biological, motivational, and dispositional factors that underlie social behavior. If hormones such as testosterone and cortisol can be validated as biological markers of personality, then social and personality psychology will become a richer science – one that extends beyond traditional personality measures and one that better understands the biological processes that regulate personality and social behavior.

# STUDY 1: HORMONES AND PERSONALITY, A MULTI-TRAIT MULTI-METHOD APPROACH

## Introduction

The purpose of Study 1 is to evaluate relationships between basal hormone levels and personality. Specifically, this study seeks to identify associations between basal T and personality as well as basal cortisol and personality using three different assessment tools: self-reports, implicit motives as measured through creative writing samples, and informant reports. Initial studies have sought to evaluate the relationship between basal hormones and self-reports of personality. Few studies, however, have investigated hormone-implicit motive or hormone-informant report associations. By comparing basal hormones to self-reports, implicit motives, and informant reports and by assessing multiple traits and motives, I can evaluate which traits assessed using which methods show the greatest convergence with basal hormone levels. Thus, this chapter seeks to expand considerably on past research by taking a multi-trait, multi-method approach to personality assessment, which has the potential to illuminate associations with diverse aspects of personality traits.

### Basal Testosterone and Self-reported Personality

If basal T is thought to tap into dominance, then it should correlate with existing psychological measures of dominance. But the literature on hormones and personality has found mixed evidence for a relationship between basal T and self-reported dominance. Although some studies demonstrated modest correlations between T levels and self-reports of dominance (Grant & France, 2001; Sellers, Mehl, & Josephs, 2007) and related traits such as aggressiveness (cf. Archer, 2006), many other studies found no evidence for such relationships (e.g., null relationship between T and aggression, Aluja & Torrubia, 2004; cf. Mazur & Booth, 1998; null relationship between T and dominance, Gray et al., 1991). As reviewed in Chapter 1, there is evidence that basal T is related to sensation-seeking (Aluja & Torrubia, 2004; Coccaro et al., 2007a; Fink et al., 2006), although some studies have failed to find such a relationship (e.g., Rosenblitt et al., 2001). Given these mixed findings in the literature, it is difficult to draw firm conclusions as to what the true associations between basal T and personality traits are.

Furthermore, very little research has evaluated basal T's relationships with the most widely accepted system of personality organization among personality psychologists: the Big Five (McCrae & Costa, 1997). A recent study found that basal T was unrelated to extraversion, neuroticism, openness, or agreeableness, but surprisingly, basal T was negatively correlated with conscientiousness in women ($r = .40$; Sellers et al., 2007). However, because this was the first empirical study to report such a relationship, it is unclear whether this effect will hold up in the face of further empirical scrutiny. Finally, little research has evaluated basal T's relationship with additional personality traits that may be related to dominance and status, such as assertiveness or the Dark Triad personality traits (Narcissism, Psychopathy, and Machiavellianism), as well as with personality constructs that are unrelated to dominance and status, such as achievement and affiliation. A more thorough empirical analysis of the convergent and discriminant validity of basal T should also assess basal T's relationships with such constructs.

### Basal Cortisol and Self-reported Personality

Cortisol levels are elevated during periods of psychological stress, and thus, one might expect basal cortisol to be positively associated with personality traits linked to negative emotion and anxiety, such as neuroticism. In support of this idea, there was a small positive correlation ($r = .17$) between basal cortisol and neuroticism in large sample of 276 adult participants (Miller et al., 1999). Another study found that high-anxious individuals had higher basal cortisol than low-anxious individuals (Brown et al., 1996). Inconsistent with these results, however, one study reported a null relationship between cortisol and neuroticism (Roy, 1996).

Other findings, in both animals and in humans, suggest that basal cortisol may also be related to extraversion. As reviewed in Chapter 1, higher cortisol has been linked to behavioral inhibition and avoidance (Kagan et al., 1987; Smider et al., 2002), a social interaction style associated with introversion. However, a large study of adults reported a *positive* correlation between basal cortisol and extraversion ($r = .17$, $p < .01$), suggesting that introversion may be linked to lower, not higher, basal cortisol levels (Miller et al., 1999). In this latter study, however, cortisol was taken during a quarantine period, which may have been a more stressful experience for extraverts than for introverts. Other studies reported a non-significant relationship between basal cortisol and extraversion (Munafò et al., 2006; Schommer, Kudielka, Hellhammer, & Kirschbaum, 1999). Overall, the evidence on basal cortisol-personality relationships is inconsistent, and thus, more research on this topic is needed.

### Improving upon previous research

There are two potential reasons for why the research to date on basal hormones and personality has yielded inconsistent results. First, sample sizes in this area of research tend to be small, which results in low statistical power. Research using larger sample sizes, multiple samples, or meta-analyses can more accurately evaluate the convergent and discriminant validity of basal hormones. Second, research on hormones and personality has tended to assess personality using self-reports. But as some theorists have argued, hormones may be tapping into an aspect of personality outside of conscious awareness (Sellers et al., 2007). For example, basal T may be tapping into an individual's *implicit* need for status. If that is the case, then basal T should not be expected to correlate strongly with self-reports. Instead, researchers should look to alternative methods for personality assessment that may offer different perspectives on personality. Two such methods that have received some attention in personality research and that hold great promise for understanding hormone-personality relationships are (1) implicit motive assessment through creative stories, and (2) informant reports.

### Basal Hormones and Implicit Motives

Research in a number of areas of psychology suggests that implicit motives – measured through individuals' creative stories in response to picture cues -- have important consequences for human behavior (McClelland, Koestner, & Weinberger, 1989). These motives are implicit in the sense that they are uncorrelated with self-reported motives and differ from self-reports in the types of behaviors they predict. Whereas self-reported motives are thought to tap into a cognitive motivational system that guides conscious and intentional behaviors in response to *social* incentives, implicit motives are thought to be part of a more primitive affect-based motivational system that spontaneously drives behaviors intended to elicit pleasurable affect in response to *natural* incentives (McClelland et al., 1989). Thus, implicit motives may provide unique insights into a person's unconscious motivational state that cannot be accessed through self-reports.

Three implicit motives in particular – power, affiliation, and achievement -- have received substantial attention from social and personality psychologists over the past half century. The implicit power motive, defined as a recurrent concern to have "impact, control, or influence over another person, group, or the world at large" (Winter, 1973), is positively associated with behaviors related to dominance, including aggressiveness and competitiveness (cf. McClelland, 1985). So might the implicit power motive also be associated with basal T levels?

Initial evidence suggests that there may be a positive relationship between basal T and the implicit power motive (Schultheiss, Campbell, & McClelland, 1999; Schultheiss et al., 2005), but the evidence has been somewhat mixed. Although two studies reported marginally significant basal T-implicit power motive correlations, ($r = .29$ in a sample of 42 male college students, Schultheiss et al., 1999; $r = .44$ in a sample of 18 male college students, Schultheiss, Dargel, & Rohde, 2003) a more recent study with a larger sample of 87 men found that time of day moderated this relationship. Basal T and the implicit power motive were unrelated across the entire sample, but among the 30 participants whose basal T levels were measured earlier in the day (between 9 AM and 1 PM), basal T was positively correlated with the implicit power motive ($r = .40$). Among the remaining participants whose basal T levels were measured later in the day (between 1 and 5 PM), basal T was uncorrelated with the implicit power motive.

The empirical evidence linking basal T to the implicit power motive in women has also been mixed. One study found a non-significant relationship between the two in a sample of 71 women (Schultheiss et al., 2005). Another study found that basal T was correlated with the implicit power motive in the 13 single women who participated in the study, but not among women the remaining 23 women engaged in close relationships (Schultheiss et al., 2003). Given these data, it is still unclear whether basal T is associated with the implicit power motive, and whether this association might be moderated by factors such as time of day, gender, or relationship status.

Furthermore, studies to date have generally failed to test whether basal T is related to the implicit affiliation or the implicit achievement motive. If T is specific to dominance, then it should be unrelated to these other motives. An empirical analysis demonstrating such null relationships would strengthen the discriminant validity of basal T as a marker of dominance. Finally, there are no studies to my knowledge that have assessed relationships between basal cortisol and implicit motives.

**Basal Hormones and Informant Reports**

Recent research suggests that informants – such as friends, significant others, siblings, and peer acquaintances – can provide unique insights into personality above and beyond self-reports (e.g., Kolar, Funder, & Colvin, 1996; Vazire, 2006a, 2006b). Indeed, informants can even predict behavior as well as or even better than the self for some types of behaviors (e.g., Vazire, 2006b). These effects are likely due, at least in part, to inaccuracies in self-reports due biases in motivation and information (cf. Vazire, 2006b).

As argued by numerous personality theorists and researchers, the self may be motivated to present his or her personality in an inaccurate way in order to be perceived by others the way he or she wants to be perceived (e.g., in a socially desirable way). Such impression management biases might introduce inaccuracy into self-reports of personality. Informants offer another perspective on personality and may be able to assess personality as well or even better than the self in some domains (Vazire, 2006b).

Initial evidence suggests that basal T is indeed related to informant reports of dominance in adolescent males (e.g., Rowe et al., 2004). But to date, no studies have tested the relationship between basal T and informant reports of dominance in male and female adults. Further, studies have not yet evaluated basal T's association with personality traits related to dominance (e.g., power, leadership), or those unrelated to dominance (e.g. openness). Finally, no research to my knowledge has assessed relationships between basal cortisol and informant-reported personality traits in human adults.

**Study 1 Overview**

The present study investigated the convergent and discriminant validity of basal hormones with a variety of personality constructs that were measured using self-reports, informant reports, and creative writing samples in order to assess implicit motives. Such a multi-trait multi-method approach to the study of hormones and personality allows for examination of important theoretical questions that have yet to be empirically tested. For example, by comparing the relationships between basal T and self-reports, basal T and informant reports, and basal T and implicit motives, I can evaluate the theoretical claim that basal T is an implicit measure of dominance.

This study used an internal meta-analysis – by aggregating data across the three data sets -- to uncover relationships between basal hormones and personality. Such an approach has three strengths in particular. First, meta-analysis is not prone to the idiosyncratic results of one particular study and instead is designed to uncover relationships that are relatively consistent across studies. Second, meta-analysis capitalizes on statistical power, which helps minimize Type II error and also allows for detection of relationships that are small in effect size. This latter strength is of particular importance in the present research because relationships between basal hormones and personality constructs are unlikely to be large, generally in the $r = .1$ to $.2$ range. Third, meta-analysis allows for more accurate estimation of effect sizes than any one study alone.

Given the large animal literature connecting basal T to social dominance and aggression, I expected some relationships between basal T and dominance, aggression, or power to emerge. Based on some initial prior research, there was also some reason to suspect a negative relationship between basal T and conscientiousness (Sellers et al., 2007). Finally, I expected basal cortisol to be related to neuroticism or extraversion.

## Method

### Participants

Participants were culled from all three samples: the leader-follower sample, the Hawk-Dove sample, and the Ultimatum/Third Party Punishment Game sample. There were a total of 389 participants in this aggregated sample (182 men). Participants were given research credit or monetary compensation for participation.

## Procedure

### ***Leader-Follower Sample***

In the Leader-Follower sample, participants reported to the lab between 11:30 AM and 4:30 P.M. to minimize the effects of circadian fluctuations in T and cortisol levels (Touitou and Haus, 2000). The experimenter led each participant to a separate room, obtained informed consent, and collected a saliva sample. The saliva samples were immediately brought to a nearby freezer for storage and were later analyzed for T and cortisol concentrations using radio immunoassay at Yerkes Biomarkers Laboratory, Atlanta, GA. After providing the saliva sample, participants filled out a variety of paper-and-pencil questionnaires in order to assess several personality traits. Information about the questionnaires included are shown in Table 2.

### ***Hawk-Dove Sample***

In the Hawk-Dove Sample, participants were recruited through fliers around the UT campus. The study consisted of two phases: an online portion and a laboratory portion.

*Self-reported personality.* All participants completed the online portion of the study prior to the laboratory portion. Participants first completed a variety of self-report online questionnaires. Table 2 includes information on all of the included self-reported personality measures.

*Implicit Motives.* After filling out these questionnaires, participants completed an online version of the Picture Story Exercise (Schultheiss et al., 2005). Participants were presented with six pictures, one at a time, and typed a short story based on each picture. The pictures used were: *boxer, women in laboratory, ship captain, couple by river,* *trapeze artists, and nightclub scene,* which are the same pictures used in research by Pang & Schultheiss (2006). In this version of the Picture Story Exercise, participants first read the following instructions:

> "The next thing you will be doing is called a Picture Story Exercise. You will be shown pictures one at a time. Basically, the idea is just to write a complete story about each picture – an imaginative story with a beginning, middle, and an end. Try to portray who the people in each picture might be, what they are feeling, thinking, and wishing for. Try to tell what led to the situation depicted in each picture and how everything will turn out in the end. At the top of each page there are some guiding questions – these should be used as guides to writing your story. You do not need to answer them specifically. Look at the picture for some seconds first. Then click the "Click here to begin writing" button and start writing whatever story comes to your mind. Don't worry about grammar, spelling, punctuation – they are of no concern here. You will have about 4 minutes for each story. There are a total of 6 pictures in this task."

Participants then clicked a hyperlink to advance to the first picture cue. The first picture was presented along with the text "Look at the picture for a few seconds. Then click the button below to begin writing." Participants then could click on a button at the bottom of the page to begin writing a story. Once participants clicked a button, they were taken to a page with the following instructions: "Please write continuously for the full 4 minutes. Don't worry about spelling, grammar, or punctuation. Press the 'Finish' button when you're done." Participants then could begin typing their story. Once the first letter of the story was typed, the timer visible on the page began to track time. If participants stopped typing for a few seconds, a dialogue box with the following prompt appeared on the screen: "Try to keep writing the entire time." If participants clicked the 'Finish' button before 4 minutes were up, the following prompt appeared: "You have not yet finished your writing time. You should try and write continuously for the entire time. Do you really want to finish now?" Once four minutes were up, the following prompt appeared: "Your time is up, but you can continue writing. Just press the finish button below when you have finished your writing." After clicking the finish button, the next picture cue was presented. Participants wrote stories for each of the six picture cues.

Three trained research assistants read and coded the stories for power, affiliation, and achievement using Winter's (1994) *Manual for Scoring Motive Imagery in Running Text*. These research assistants trained for two months on the Winter (1994) system prior to beginning coding on actual participant data, and reached greater than 80% reliability (an index of concordance) with calibration materials prescored by an expert included in Winter (1994).

According to the Winter (1994) manual, power is scored whenever a story character shows concern with having impact by strong, forceful actions, persuading or convincing others, controlling, checking up on, or influencing emotions in other people or the world at large. Helping others when the help is not requested is also scored for power. Achievement is scored whenever a character shows concern for attaining a standard of excellence such as in the mention of winning or competition, negative emotional response to failure, or mention of a unique accomplishment. Affiliation is scored whenever a character expresses concern for establishing, maintaining, or restoring friendly relations with others or expresses sadness or other negative emotion about separation or disruption of a relationship.

*Laboratory portion of Sample 2 study.* For the laboratory portion of this study, participants reported to the lab in same-sex pairs between 11:00 AM and 5:30 PM and provided three saliva samples throughout the course of the experiment. The samples were immediately brought to a nearby freezer for storage and were later analyzed for T and cortisol concentrations using DSL radio immunoassay kits at Yerkes Biomarkers lab, Atlanta, GA. After providing a saliva sample, participants then engaged in some economic decision making tasks and were paid for their participation. For the purposes of the present study, I will use data on implicit motives, self-reported personality, and hormones. Economic decision data from this study will be reported in Study 3.

***Ultimatum/Third Party Punishment Game Sample***

Participants in this sample were recruited through craigslist.org and from fliers on the UT campus. In order to participate in the study, participants had to be between 18 and 30 years old, and could not have taken more than two psychology or economics courses. Participants were comprised of undergraduate students, graduate students, and non-student community members. Participants filled out self-report measures prior to coming to the lab (see Table 2). Participants provided two saliva samples during the laboratory portion of the study, and were paid according to the economic decisions they made during the study. Only testosterone levels were assayed by the time this document was completed. Cortisol levels were not yet available.

*Informant Reports.* During the online portion of the study, participants were asked to nominate at least one person to provide information on their personality. Participants provided email addresses for these informants. I emailed informants one at a time using standardized text. The email indicated that [Name of participant] (referred subsequently to as “X”) recently participated in a psychology study and nominated them to provide information about X’s personality. Informants were then given a unique id number and were directed to a website that included a personality questionnaire about X, which included 76 items, including items designed to assess dominance, assertiveness, the Big 5 personality traits, and several other constructs (e.g., affiliation, achievement). Details about the constructs included in the informant questionnaire are included in Table 2, and details about the specific items are included in Appendix A. The questionnaire took approximately 15 to 20 minutes to complete. Informants filled out an online consent form prior to filling out the questionnaire. Informants were told that their responses were for psychological research only and would not be shared with X. They were not given compensation for their participation. If informants did not complete the questionnaire after the first email, a second reminder email was sent. Informant compliance was quite reasonable (at least one informant rating for 81% of the sample).

*Table 2. Description of individual difference variables from the three samples*

| Sample | Method | Construct | Measures |
|---|---|---|---|
| Leader-Follower | Self-reports | Dominance | Personality Research Form-Power subscale (Jackson, 1967) |
| | | Social Dominance Orientation | Social Dominance Orientation (Pratto et al.,1994). |
| | | Assertiveness | Assertiveness Facet of NEO-PI-R (Costa & McCrae, 1995) |
| | | Extraversion | Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003) |
| | | Neuroticism | Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003) |
| | | Openness | Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003) |
| | | Agreeableness | Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003) |
| | | Conscientiousness | Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003) |
| | | Blirtatiousness | BLIRT (Swann & Rentfrow, 2001) |
| | Hormones | Testosterone | Salivary testosterone (one sample), DSL radioimmunoassay kit |
| | | Cortisol | Salivary cortisol (one sample), DSL radioimmunoassay kit |
| Hawk-Dove | Self-reports | Dominance | Personality Research Form-Power subscale (Jackson, 1967) |
| | | Social Dominance Orientation | Social Dominance Orientation (Pratto et al.,1994). |
| | | Assertiveness | Assertiveness Facet of NEO-PI-R (Costa & McCrae, 1995) |
| | | Extraversion | Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003) |
| | | Neuroticism | Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003) |
| | | Openness | Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003) |
| | | Agreeableness | Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003) |
| | | Conscientiousness | Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003) |
| | | Machiavellianism | Mach-IV (Christie & Geis, 1970) |
| | | Psychopathy | SRP-III (Hare, 1985) |
| | | Narcissism | Ames NPI (Ames et al., 2006) |
| | Picture Story Exercise (implicit motives) | Power | Winter (1994) coding system for implicit motives |
| | | Achievement | Winter (1994) coding system for implicit motives |
| | | Affiliation | Winter (1994) coding system for implicit motives |
| | Hormones | Testosterone | Salivary testosterone (three samples), DSL radioimmunassay kit |
| | | Cortisol | Salivary cortisol (three samples), DSL radioimmunoassay kit |

(Table 2 Continued)

| **Sample** | **Method** | **Construct** | **Measures** |
|---|---|---|---|
| Ultimat./ Third Party Punish. | Self-reports | Assertiveness | Assertiveness Facet of NEO-PI-R (Costa & McCrae, 1995) |
| | | Extraversion | Big Five Inventory (John et al., 1991) |
| | | Neuroticism | Big Five Inventory (John et al., 1991) |
| | | Openness | Big Five Inventory (John et al., 1991) |
| | | Agreeableness | Big Five Inventory (John et al., 1991) |
| | | Conscientiousness | Big Five Inventory (John et al., 1991) |
| | | Aggression | Buss & Perry (1992) |
| | | Impulsive Sensation-Seeking | (Zuckerman, 1991) |
| | Informant Reports | Dominance | selected items (see Appendix A) |
| | | Assertiveness | selected items (see Appendix A) |
| | | Extraversion | Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003) |
| | | Neuroticism | Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003) |
| | | Openness | Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003) |
| | | Agreeableness | Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003) |
| | | Conscientiousness | Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003) |
| | | Machiavellianism | selected items (see Appendix A) |
| | | Psychopathy | selected items (see Appendix A) |
| | | Narcissism | selected items (see Appendix A) |
| | | Sensation Seeking | selected items (see Appendix A) |
| | | Self-Esteem | selected items (see Appendix A) |
| | | Masculinity | selected items (see Appendix A) |
| | | Femininity | selected items (see Appendix A) |
| | | Depression | selected items (see Appendix A) |
| | | Political Orientation | selected items (see Appendix A) |
| | | Likeability | selected items (see Appendix A) |
| | | Achievement | selected items (see Appendix A) |
| | | Affiliation | selected items (see Appendix A) |
| | | Leadership | selected items (see Appendix A) |
| | Hormones | Testosterone | Salivary testosterone (two samples), DSL radioimmunassay kit |

# Results

## Hormone Assays

Saliva samples were shipped frozen overnight to Yerkes Endocrine Core Laboratory, Emory University, Atlanta, GA. Saliva samples from the Leader-Follower Sample and the Hawk-Dove sample were assayed for testosterone and cortisol using radioimmunoassay kits purchased from Diagnostic Systems Laboratories, Inc. Saliva samples from the Ultimatum Game sample were analyzed for testosterone only. Cortisol data were not yet available for this third sample. Across all three samples, intra-assay variability for testosterone averaged 8%, and inter-assay variability averaged 11%. In the two samples in which cortisol was assayed, intra-assay variability for cortisol averaged 6%, and inter-assay variability averaged 10%.

## Meta-analysis

Because many of the same self-reported personality traits and hormones were assessed in multiple studies, a meta-analysis was conducted across the three studies. For the Hawk-Dove and Ultimatum/Third Party Punishment Game samples in which multiple hormone samples were taken, cortisol and testosterone levels were averaged across the various time points because there was a high degree of temporal stability in hormone samples (see Tables 3 and 4). The cortisol distributions were skewed, and thus, they were log-transformed. For the Hawk-Dove sample, alpha for average levels of testosterone across the three time points was .93., and alpha for log-transformed and averaged levels of cortisol across the three time points was .91. For the Ultimatum/Third Party Punishment Game sample, alpha for testosterone across the two time points was .90.

There were differences in the log-transformed mean cortisol levels across the three samples $F(1, 271) = 19.79$, $p < .001$. Therefore, cortisol levels were standardized within sample by converting the log-transformed scores to z-scores. Similarly, testosterone levels were standardized within sex and within sample by converted them to z-scores. Initial analyses demonstrated that the time of day predicted basal testosterone, $r(384) = -.14$, $p < .01$ and basal cortisol, $r(273) = -.33$, $p < .01$. Therefore, time of day was controlled for when assessing hormone-personality relationships.

*Table 3. Correlations between hormone measures in the Hawk-Dove Sample*

| | **Time 1 T** | **Time 2 T** | **Time 3 T** | **Time 1 Cort** | **Time 2 Cort** |
|---|---|---|---|---|---|
| Men and Women Combined (n = 98) | | | | | |
| **Time 2 T** | .97** | | | | |
| **Time 3 T** | .95** | .98** | | | |
| **Time 1 Cort** | .17$^{\dagger}$ | .14 | .09 | | |
| **Time 2 Cort** | .31** | .30** | .24* | .77** | |
| **Time 3 Cort** | .28** | .29** | .28** | .65** | .86** |
| Men Only (n = 42) | | | | | |
| **Time 2 T** | .87** | | | | |
| **Time 3 T** | .80** | .91** | | | |
| **Time 1 Cort** | .19 | .10 | -.01 | | |
| **Time 2 Cort** | .19 | .11 | .00 | .71** | |
| **Time 3 Cort** | .04 | .05 | .04 | .50** | .82** |
| Women Only (n = 56) | | | | | |
| **Time 2 T** | .78** | | | | |
| **Time 3 T** | .72** | .82** | | | |
| **Time 1 Cort** | .20 | .18 | .06 | | |
| **Time 2 Cort** | .09 | .28* | .07 | .83** | |
| **Time 3 Cort** | .12 | .24$^{\dagger}$ | .18 | .78** | .88** |

Note. T = Testosterone, Cort = Cortisol. Cortisol levels were log-tranformed to remove skew in the distribution.

*Table 4. Correlations between hormone measures in the Ultimatum/Third Party Punishment Sample*

| | **Time 1 T** |
|---|---|
| Men and Women Combined (n = 115) | |
| **Time 2 T** | .82** |
| Men Only (n = 54) | |
| **Time 2 T** | .86** |
| Women Only (n = 61) | |
| **Time 2 T** | .79** |

Note. T = Testosterone.

Results of the meta-analysis are reported in Table 5. Partial correlations between basal hormone levels and self-reported personality traits controlling for the time of day were computed. As shown, basal testosterone was negatively associated with conscientiousness, especially in women. However, basal testosterone was unrelated to self-reports of assertiveness, dominance, or the social dominance orientation. In addition, basal cortisol was negatively associated with extraversion in both sexes. Interestingly, basal cortisol also showed a statistically significant positive relationship with the Social Dominance Orientation in men only. Table 5 collapses reports correlations collapsed across the three samples, but the correlations found within each independent sample are reported in Appendix B.

*Table 5. Meta-analysis: Partial correlations between basal hormone levels and personality traits, controlling for the time of day*

| **Self-Reported Personality Trait** | **Men and Women** | | **Men** | | **Women** | |
|---|---|---|---|---|---|---|
| | T[a] | Cort[b] | T[a] | Cort[b] | T[a] | Cort[b] |
| | r (SE) | r (SE) | r (SE) | r (SE) | r (SE) | r (SE) |
| 1. Extraversion | -.03 (.05) | -.13* (.06) | .06 (.08) | -.10 (.10) | -.11 (.07) | -.14† (.09) |
| 2. Agreeableness | .02 (.05) | .09 (.06) | .07 (.08) | .12 (.10) | -.02 (.07) | .07 (.09) |
| 3. Conscientiousness | -.10* (.05) | -.01 (.06) | -.02 (.08) | -.11 (.10) | -.17* (.07) | .06 (.09) |
| 4. Emotional Stability | .00 (.05) | .01 (.06) | -.08 (.08) | -.06 (.10) | .08 (.07) | .06 (.09) |
| 5. Openness | -.04 (.05) | -.06 (.06) | -.02 (.08) | -.03 (.10) | -.05 (.07) | -.08 (.09) |
| 6. Assertiveness | .04 (.05) | -.06 (.06) | .02 (.08) | -.12 (.10) | .05 (.07) | -.01 (.09) |
| 7. Dominance | .04 (.05) | -.01 (.06) | .05 (.08) | -.04 (.10) | .03 (.07) | .02 (.09) |
| 8. Social Dominance Orientation | .02 (.05) | .10 (.06) | .08 (.08) | .25** (.10) | -.03 (.07) | -.03 (.09) |

†p< .10, *p< .05, **p < .01, T = Testosterone. Cort = Cortisol.

a. Partial correlations between basal testosterone (z-scores, standardized within sex and within sample) and personality traits (z-scores, standardized within sample), controlling for time of day.

b. Partial correlations between log-transformed basal cortisol (z-scores, standardized within sample) and personality traits (z-scores, standardized within sample), controlling for time of day

Notes: r = correlation coefficient, SE = standard error of r. All analyses for T and personality include participants in all three samples (N = 389 total, 182 men, 207 women). All analyses for Cort and personality include participants from Leader Follower Sample and the Hawk-Dove Sample combined (N = 274, 128 men, 146 women). Because of the large number of correlations reported, it is possible that some of the correlations may be statistically significant due to Type I error.

*Table 6. Partial Correlations between basal hormones and personality traits, controlling for the time of day.*

| | Men and Women | | Men | | Women | |
|---|---|---|---|---|---|---|
| **Self-Reported Personality Trait (Sample)** | T[a] | Cort[b] | T[a] | Cort[b] | T[a] | Cort[b] |
| 1. Blirtatiousness (LF) | .07 | -.02 | -.03 | -.02 | .17 | .02 |
| 2. Narcissism (HD) | -.01 | -.03 | -.04 | -.19 | .05 | -.04 |
| 3. Machiavellianism (HD) | -.06 | .07 | .04 | -.08 | -.11 | .15 |
| 4. Psychopathy[c] (HD) | .02 | .10 | -.07 | .01 | .00 | .18 |
| 5. Aggression (UG/3PPG) | .10 | -- | .07 | -- | .13 | -- |
| 6. Impulsive Sensation-Seeking (UG/3PPG) | .14 | -- | -.03 | -- | .28* | -- |
| **Implicit Motives (Sample)** | | | | | | |
| 7. Achievement (HD) | .17† | -.02 | .11 | .04 | .21 | -.02 |
| 8. Affiliation (HD) | .16 | .08 | -.07 | .04 | .29* | .06 |
| 9. Power (HD) | -.03 | .03 | -.33* | -.04 | .20 | -.02 |

†$p < .10$, *$p < .05$, **$p < .01$, T = Testosterone. Cort = Cortisol. LF = Leader Follower Sample, HD = Hawk-Dove Sample, UG/3PPG = Ultimatum/Third Party Punishment Sample.

a. Partial correlations between basal testosterone (z-scores, standardized within sex) and personality traits, controlling for time of day.
b. Partial correlations between log-transformed basal cortisol and personality traits, controlling for time of day
c. Gender was also entered as a covariate for this trait because men scored higher than women on average.

Note: Because of the large number of correlations, it is possible that some of the correlations may be statistically significant due to Type I error.

## Other Personality Traits

Each sample also had some self-reported personality measures that were not included in any of the other samples. The partial correlations between hormones and personality for these additional measures are shown in Table 6. Basal testosterone was unrelated to aggression, machiavellianism, narcissism, pscyhopathy, or blirtatiousness, but basal testosterone did show a positive correlation with impulsive sensation-seeking in women.

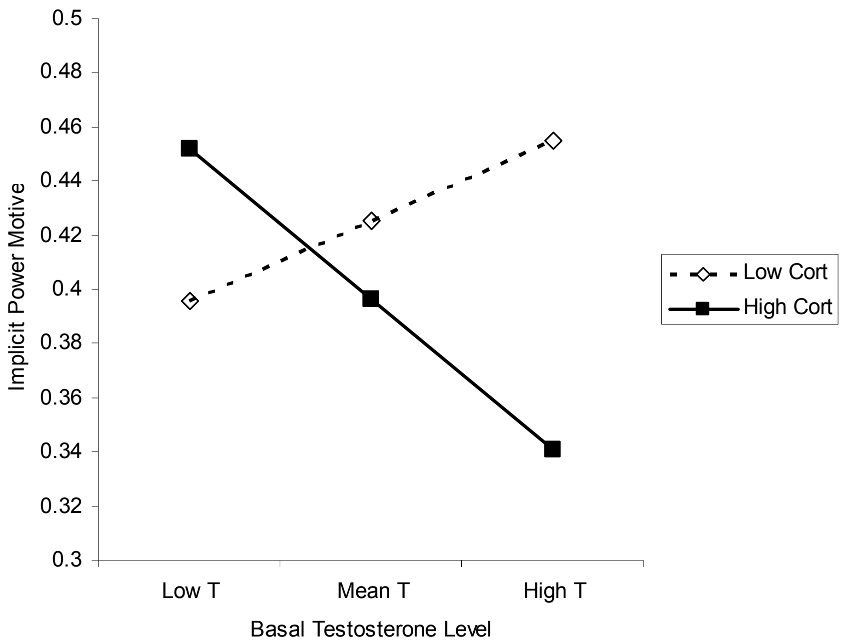
### *Implicit Motives*

To calculate implicit power motive scores for each participant, the number of power themes across the six stories was divided by the total word count across the six stories. This number was then multiplied by 100, which yielded an index of the total number of power themes per 100 words. The same formula was used to calculate implicit affiliation motive and implicit achievement motive scores.

Partial correlations between implicit motives -- which were assessed in the Hawk-Dove sample only -- and hormones are shown in Table 6. Contrary to our expectations, there was a negative relationship between basal testosterone and the power motive in men, and a positive relationship between the basal testosterone and the affiliation motive in women. The time of the experiment did not moderate any of the relationships between implicit motives and basal hormones (p's > .30). However, a multiple regression across both men and women showed that there was a statistically significant basal testosterone x basal cortisol interaction for the power motive, R-squared change = 4.5%, $F(1, 90) = 4.29$, $p < .05$, but not for the affiliation or achievement motives, p's > .30. The three-way basal testosterone x basal cortisol x gender interaction on power motive was non-significant, (1, 87) = .002. To interpret the statistically significant basal testosterone x basal cortisol interaction on power motive, the multiple regression model slopes were used to plot implicit power motive scores at the basal T mean and basal cortisol means, as well as one standard deviation above and below these means. As shown in Figure 1, individuals high in testosterone and low in cortisol showed high implicit power motive scores, whereas individuals high in testosterone and high in cortisol showed low implicit power motive scores. Even though the basal testosterone x basal cortisol interactions were not statistically significant when the data were analyzed for each sex individually (p's > .20), Figure 1 also depicts the pattern of data for men and women separately.

*Figure 1. Implicit Power Motive as a Function of Basal Testosterone and Basal Cortisol*

*(a) Both sexes combined*




(b) *Men only.*

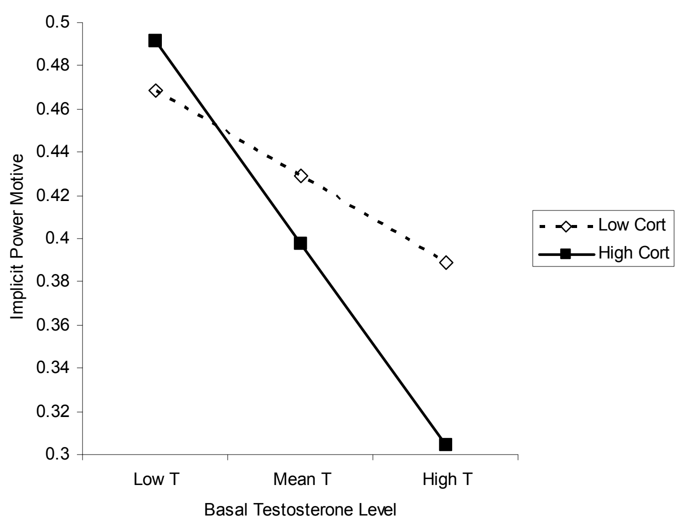
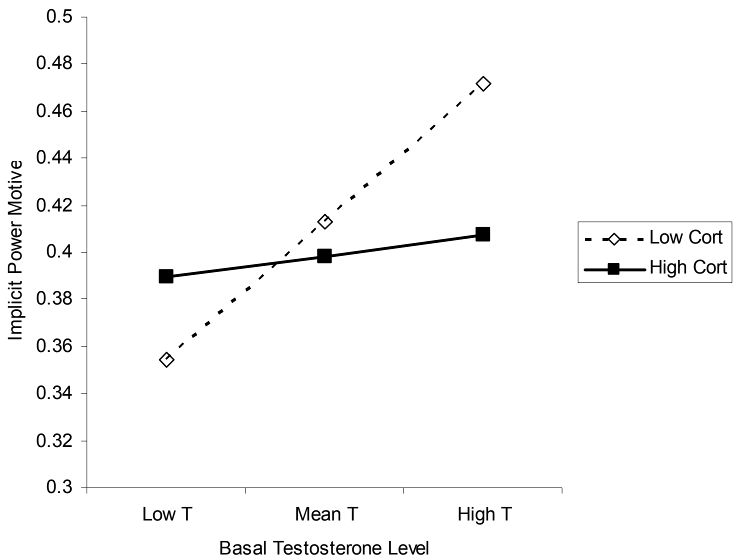


*Figure 1 (con't).*

*(c) Women Only.*



*Informant Reports.* Ninety-four out of the 116 participants (81%) in the Ultimatum/Third Party Punishment Sample had at least one informant rate their personality, but some participants had two or three informants provide ratings. When more than one set of informant ratings for a given participant was provided, these ratings were averaged. Appendix A includes the items and traits assessed using informant reports. Table 7 shows the self-other agreement for traits that were rated by both the self and informants. There was modest agreement on most traits except for openness.

*Table 7. Self-informant Agreement in the Ultimatum/Third Party Punishment Game Sample*

| **Informant-Reported Personality Trait** | **Self-Informant Agreement** |
|---|---|
| 1. Extraversion | .59** |
| 2. Agreeableness | .44** |
| 3. Conscientiousness | .63** |
| 4. Emotional Stability | .58** |
| 5. Openness | -.10 |
| 6. Assertiveness | .56** |
| 7. Dominance | .37** |
| 8. Aggression | .39** |
| 9. Sensation Seeking | .22* |
| **Average r** | **.41** |

Next, partial correlations were computed between basal testosterone and selected informant-rated personality traits, controlling for the time of the experiment. These partial correlations are reported in Table 8. As shown, the negative correlation between women's basal testosterone and conscientiousness found with self-reported personality replicated with informant reports. Interestingly, informant reports showed a positive correlation between basal testosterone and conscientiousness in men, which was not detected with self-reports. Another set of important findings was that testosterone was positively correlated with masculinity, whereas testosterone was negatively correlated with femininity.

*Table 8. Partial correlations between basal testosterone and informant-reported personality traits (Ultimatum Game/Third Party Punishment Sample), controlling for time of day*

| **Informant-Reported Personality Trait** | **Men and Women (n = 94)** | **Men Only (n = 43)** | **Women only (n = 51)** |
|---|---|---|---|
| 1. Extraversion | .09 | .14 | .06 |
| 2. Agreeableness | -.10 | -.03 | -.19 |
| 3. Conscientiousness | -.03 | .32* | -.33* |
| 4. Emotional Stability | .04 | .29† | -.18 |
| 5. Openness | -.05 | .24 | -.37* |
| 6. Assertiveness | .06 | .11 | .06 |
| 7. Dominance | .07 | .00 | .14 |
| 8. Aggression | .01 | -.24 | .26† |
| 9. Sensation Seeking | .19† | .28† | .16 |
| 10. Machiavellianism | .07 | -.12 | .25† |
| 11. Psychoticism | .16 | .03 | .27† |
| 12. Narcissism | .02 | -.29† | .25† |
| 13. Self-esteem | .01 | .19 | -.12 |
| 14. Masculinity[a] | .21* | .31* | .14 |
| 15. Femininity[a] | -.22* | -.15 | -.29* |
| 16. Depression | -.01 | -.35* | .27† |
| 17. Political Orientation | .00 | .10 | -.12 |

a. The analysis for men and women combined controlled for experiment time as well as participant sex because there was a strong sex difference such that women were rated as more feminine and men were rated as more masculine.

# Discussion

This study sought to replicate and extend previous research on hormones and personality using a multi-trait multi-method approach, and by pooling together independent samples when possible. This research strategy demonstrated several important relationships between hormones and personality.

## Hormones and The Big Five Personality Traits

First, there was a negative association between basal testosterone and conscientiousness in women. This effect was consistent across self and informant reports of personality. Such a relationship serves to replicate research by Sellers and colleagues (2007). A strength of the current study over this previous study was that the present study employed a meta-analysis of three large independent samples, whereas Sellers and colleagues studied a much smaller sample of 40 women. Now that Sellers et al's findings have been replicated, we can be much more confident that a negative relationship between basal T and conscientiousness in women does indeed exist. The next steps should involve gaining a deeper understanding of the nature of this relationship. For instance, one direction for future research is to investigate which facet or facets of conscientiousness are most closely related to basal testosterone in women. One possibility is that basal testosterone is associated almost exclusively with the impulsivity facet of conscientiousness. This interpretation is consistent with the finding that basal testosterone was also positively related to impulsive sensation-seeking among women in the present study. It is also consistent with some previous research that has documented a connection between high testosterone and disinhibition/sensation-seeking (Aluja &

Torrubia, 2004; Aluja & Garcia, 2005).

This study also unearthed a negative relationship between basal cortisol and extraversion across both sexes. This finding is especially important because some previous research has reported a null relationship between basal cortisol and extraversion (Schommer, Kudielka, Hellhammer, & Kirschbaum, 1999). This past research, however, used a much smaller sample of 81 participants, whereas the meta-analysis presented here used over 200 participants. It is not at all surprising that null relationships of small effect sizes (e.g., $r$ of less than .2) would not be found using small sample sizes. A link between basal cortisol and extraversion is consistent with animal and human research, which suggests that high cortisol is linked to behavioral inhibition and avoidance (Kagan et al., 1987; Smider et al., 2002). Future research should follow up on this relationship and attempt to determine the direction of causality as well as identify potential mediators.

**Hormones, Aggression, and Dominance**

Inconsistent with several theoretical models but consistent with previous mixed findings on hormones and personality, there was no relationship between basal testosterone and individual differences in aggression or dominance in the present study. These null effects were found with both self and informant reports. Thus, it seems that the common stereotype of a dominant, aggressive person being high in testosterone may not be true. At the same time, there is evidence that basal testosterone does predict aggressive and dominant behaviors. So what can explain this paradox – that is, that basal testosterone does seem to be able to predict social behaviors associated with aggression and dominance, but does not seem to be consistently related to self-reports or informant reports of aggression or dominance? One possibility, as argued by Josephs et al., (2006), is that basal testosterone may only predict dominance under conditions of competition, social instability, or status threat. According to this argument, high testosterone individuals may not be *chronically* dominant and aggressive people across different situations; instead, they may exhibit aggression or dominance in status-relevant situations. This interpretation is consistent with the animal research, which shows a relationship between testosterone and social behavior only during periods of social competition (e.g., Wingfield et al., 1990).

This study also demonstrated for the first time a positive relationship between basal cortisol and social dominance orientation. This finding is particularly impressive because it emerged in a large meta-analysis which pooled data across multiple samples. Such a finding provides a new direction for future research. Although this relationship has yet to be reported in the literature, it is quite consistent with system justification theory (e.g., Jost et al., 2003). Individuals high in social dominance orientation endorse the existence of social hierarchies in society and have a conservative political orientation. According to system justification theory, this motivation to maintain the status quo may come from several sources of anxiety, such as anxiety over death or anxiety surrounding uncertainty in one’s social environment. Although it is unclear what influences what, it is possible that individuals adopt a more conservative and system-justifying set of beliefs because they face greater levels of fear and anxiety, as reflected by their higher levels of basal cortisol. Of course, such an interpretation is merely speculative at this point, but future research can measure additional variables surrounding system justifying beliefs and life stress and anxiety in order to determine the mechanisms that explain the social dominance orientation-cortisol relationship that was found in the present study.

## Hormones and Implicit Motives

Another series of interesting findings concerns implicit motive-hormone relationships. Inconsistent with our expectations, there was a negative relationship between basal testosterone and the power motive in men, as well as a positive relationship between basal testosterone and the affiliation motive in women. However, the testosterone-power relationship is difficult to interpret because it was superseded by a testosterone x cortisol interaction across both sexes, such that those individuals who had both high testosterone and low cortisol showed high power motive scores, whereas those who had high testosterone and high cortisol showed low power motive scores. This latter finding has yet to be reported, but is consistent with other research on testosterone-cortisol interactions as predictors of behavior. For instance, Popma et al. (2007) found that a testosterone-cortisol interaction explained variance in aggression among a sample of delinquent male adolescents such that boys high in testosterone and low in cortisol showed the most aggressive tendencies. These findings dovetail nicely with the present findings and suggest that high testosterone coupled with low cortisol may be a risk factor for greater power motivation and aggression.

## Limitations

There were some clear strengths to the present study, including the use of meta-analysis, and the use of multiple methods to assess personality. However, there were also some important limitations that are worth noting. First, the broad data-driven approach to assessing relationships between hormones and personality traits was certainly interesting and achieved the goal of discovering new relationships (e.g. cortisol and social dominance orientation). At the same time, this empirical approach can also be criticized as being too atheoretical. In fact, some of the findings that emerged from this study were not expected. Future studies should use the findings from the present study, attempt to integrate them with the existing psychological research, and design follow-up studies to test theoretically-derived predictions.

A second limitation was the relatively small sample size that was used to assess relationships between hormones, implicit motives, and informant-reported personality traits. Implicit motives and informant-reported personality ratings were only available for one of the samples. Although some interesting findings emerged from these analyses, such as the testosterone-cortisol interaction as a predictor of implicit power motive, these findings must be replicated using additional samples in order to gain greater confidence in them. Additionally, there some marginally significant findings of interest (e.g., a marginally significant positive relationship between T and informant-reported emotional stability in men) that should be followed up to see if they replicate in a larger sample.

# STUDY 2: HORMONES AND SOCIAL BEHAVIOR IN LEADER-FOLLOWER INTERACTIONS

## Introduction

Study 1 established some important relationships between basal hormones levels and personality. The purpose of the present study (Study 2) and subsequent studies (Studies 3 and 4) is to directly test whether basal hormones are associated with social behavior in meaningful social interactions. Research on basal T, for example, has studied its effects on attention (Josephs et al., 2006; van Honk et al., 1999), cognition (Josephs et al., 2003, 2006; Newman et al., 2005), physiological arousal (Josephs et al., 2006; Mehta et al., under review), and affect (Josephs et al., 2006), but surprisingly little research has been conducted on basal T's relationship to social behaviors. The present study investigated basal hormones and social behavior in one particular domain in which social status is relevant: leader-follower social interactions.

### Personality and Leadership

The study of leadership has been an important area of empirical research for social and personality psychologists (Hogan & Kaiser, 2005). One question in particular that has received substantial attention in the leadership literature is: what personality traits are associated with leadership? In a large meta-analysis of 73 different samples, Judge and colleagues (2002) found that high extraversion was the most consistent predictor of leadership across settings and different criteria for assessing leadership. Extraversion's two major facets – dominance and sociability – were both important for leadership. In addition to extraversion, conscientiousness, emotional stability, and openness to experience were all positively related to leadership, although to a lesser extent than extraversion. Research on social status also finds the most consistent support for extraversion as a predictor of high status (Anderson et al., 2001). In studies of student social groups – such as sororities, fraternities, and dormitory floors – extraversion was the strongest predictor of being perceived as high status. This finding held up across the sexes and across different social groups.

Although the studies reviewed above have made substantial headway in understanding the personality traits that predict leadership, much less is known about the biological systems, such as the endocrine systems, that may also be associated with leadership. In the following section, I review the evidence suggesting that basal hormones may be relevant to leader-follower dynamics.

**Hormones and Leadership**

As reviewed in Chapter 1, the animal literature suggests that high T levels may underlie the motivation to gain or maintain high status, including aggressive behaviors in response to status threats, as well as high social rank. Furthermore, high T or short-term rises in T have also been linked to behaviors associated with dominance in human adults, including aggression (Archer, 2006), greater competitiveness after a status loss (Mehta & Josephs, 2006), and an absence of smiling (Cashdan, 1995), considered a dominant facial expression. Because leadership brings with it the ability to exert power and control over others, it seems plausible that levels of T may regulate who is more likely to behave more dominantly in such high status positions.

There is some evidence supporting this logic in research on adolescent boys (Rowe et al., 2004). One study found that testosterone levels across the development period (ages 9 to 15) were positively correlated with an average of self and parent ratings of leadership, but only among boys in prosocial environments (operationalized as an absence of deviant peers). Among those boys in antisocial environments (operationalized as definitely having deviant peers), testosterone was unrelated to leadership, although it was related to anti-social behaviors. This study is important because researchers have tended to focus on the negative behaviors associated with testosterone (aggression, violence, etc.) But this study suggests that testosterone may be associated with prosocial behaviors (e.g., leadership), at least for individuals in prosocial environments.

In another study, 13-year old boys interacted with unfamiliar peers, who then rated the boys on a variety of traits, including social dominance (Schaal et al., 1996). The study found that T levels were positively correlated with peer ratings of social dominance. These studies indicate that T levels are associated with social dominance and leadership in adolescent males, but the relationship between T and leadership behaviors has not yet been tested in adult men and women. The present study seeks to address this large gap in the literature.

No work has directly examined cortisol and leadership behavior, but indirect evidence suggests that there may be a relationship between them. Indeed, low cortisol was associated with extraversion in Study 1 as well as in other human and animal work (Kagan et al., 1987; Smider et al., 2002). Although not true in Study 1, other studies have shown that low cortisol is linked to high emotional stability (Miller et al., 1999). Both extraversion and emotional stability predicted leadership in the meta-analysis discussed above (Judge et al., 2002), and thus, it seems plausible that low levels of cortisol might also predict better leadership.

Another possibility is that the interaction between testosterone and cortisol may be associated with leadership. Previous research suggests that the testosterone-cortisol interaction predicted aggression (Popma et al., 2007) such that individuals high in testosterone and low in cortisol showed the greatest tendency toward aggression, and Study 1 found that the testosterone-cortisol interaction predicted implicit power motive scores in a similar fashion. Given these findings, it could be the case that neither hormone alone is independently linked to leadership, but that a combination of the two hormones is: high testosterone and low cortisol might lead to better leadership.

**Study 2 Overview**

The primary goal of the present study was to investigate whether basal hormones would predict social behaviors in leader-follower interactions. In this study, participants provided self-reports of personality traits, a saliva sample for basal T and basal cortisol measurement, and interacted with another participant as leader or follower on a dyadic cognitive task. The task was videotaped, and interactions were observed and rated for a variety of social behaviors by independent judges. Based on the extant body of work linking basal T to dominance in status-relevant contexts (Archer, 2006), I predicted that basal T would predict dominant leadership behaviors. However, given the finding from Study 1 and previous research (Popma et al., 2007) demonstrating that T and cortisol interact to predict power and aggression, I also thought it possible that basal T and basal cortisol might interact such that high testosterone coupled with low cortisol would lead to more dominant leadership behaviors. This hypothesis was also tested.

A secondary goal of Study 2 was to compare the predictive validity of basal hormones to the predictive validity of self-reports. Based on prior work on personality and leadership, I expected extraversion to show a strong relationship to leadership behaviors in the present study. I tested whether basal hormones would predict leadership behaviors above and beyond self-reported personality.

# Method

## Participants

126 participants (64 men) took part in a study on hormones, personality, and leadership in exchange for credit toward a research participation requirement. Of these participants, 100 participants (50 men) were videotaped as they interacted with one another as leader and follower. For the purposes of the present research, only these 100 participants were included in the final sample.

## Procedure

Participants reported to the lab in same-sex pairs between 11:30 A.M. and 4:30 P.M. to minimize the effects of circadian fluctuations in T and cortisol levels (Touitou and Haus, 2000). The experimenter led each participant to a separate room, obtained informed consent, and collected the first saliva sample. The samples were immediately brought to a nearby freezer for storage and were later analyzed for T and cortisol concentrations using radio immunoassay. After providing the saliva sample, participants filled out a variety of paper-and-pencil questionnaires in order to assess several personality traits, including the Big 5, assertiveness, dominance, social dominance orientation, and blirtatiousness. Information about the questionnaires included are shown in Table 2.

After filling out the questionnaires, participants were told that the study was trying to understand the individual difference variables associated with leadership, and that as part of the study, they would be interacting with another participant on a series of tasks in which one person would be the leader and the other person would be the follower. Participants were then told that in order to determine which of the two participants would make the better leader, that the two of them would be taking a leadership test. Participants were administered an ostensible test of leadership, which included items from the Overclaiming Questionnaire (Paulhus & Harms, 2004) and some logic items of medium difficulty taken from the GRE-Analytic section. After completing the test, the experimenter told participants to wait while he or she scored the items from the test for leadership ability. After approximately five minutes, the experimenter returned and reported to participants a leadership score out of 100. The experimenter said that whoever received the higher score would be the leader. In reality, one of the two participants was randomly assigned to be leader and the other to be follower. Participants randomly assigned to leader were told that they received a leadership score of 86 out of 100, while participants randomly assigned to follower were told they received a score of 79 out of 100.

***Leader-Follower Block Design Task.***

After receiving their scores, followers were brought to an individual room and told to wait. The experiment then explained to leaders the leader-follower task. Once the leader understood the instructions for the task, he or she went to get the follower, explained the instructions to them, and began the task. The task used was the WAIS-III Block Design Task (Wechsler, 1997). In this task, an individual is given a series of blocks and must use them to make a picture. The leader stood behind the follower, who was seated in front of a series of blocks. The experimenter handed block design pictures to the leaders, one at a time. Leaders directed followers using verbal commands only (they could not point to blocks) on how to move the blocks in order to make the design of interest. Followers were not shown a picture of the design. After the leader-follower team completed the design, the leader indicated to the follower to stop the timer. The experimenter recorded the time it took each pair to finish the design and whether it was correct or incorrect. Next, the experimenter presented the next design. A total of nine designs were completed. The entire interaction was videotaped.

After this first leader-follower interaction, the experimenter told participants that because the study team was not sure if the leadership score given by the leadership test was an accurate measure of leadership ability in this particular context, the two participants would now switch leader-follower roles. Therefore, leaders and followers switched positions, and repeated the block design task using nine new block design puzzles. The entire interaction was videotaped. Such a within-subjects design was used in order to measure leadership behaviors in *all* study participants, not just in half of the sample.

***Judges' ratings.***

Research assistants watched videotapes and generated lists of classes of behaviors/traits that were observable for leaders and followers. The research assistants and I met and narrowed the lists down to the items in Table 9. Leaders on the block design task were rated on 19 different items, and followers were rated on 13 items. Seven research assistants watched the leader-follower interactions and made global ratings of the leaders' and follower' behaviors on a 7-point scale (1 = strongly disagree, 7 = strongly agree).

*Table 9. Items that judges rated in leader-follower interactions.*

| Leader Behaviors | Follower Behaviors | Factor (for Follower items) |
|---|---|---|
| 1. Engaged | 1. Engaged | Followership |
| 2. Bored | 2. Bored | Followership |
| 3. Leader-like | 3. Follower-like | Followership |
| 4. Energetic | 4. Interested | Followership |
| 5. Confident | 5. Enthusiastic | Followership |
| 6. Shy/Timid | 6. Quiet | Communication |
| 7. Gave clear instructions | 7. Good at following instructions | Followership |
| 8. Comfortable | 8. Relaxed | Followership |
| 9. Assertive | 9. Responsive to leader | Followership |
| 10. Directive | 10. Cooperative | Followership |
| 11. Indecisive | 11. Annoyed | Followership |
| 12. Dominant | 12. Talkative | Communication |
| 13. Comfortable giving instructions | 13. Asked the leader questions | Communication |
| 14. Nervous | | |
| 15. Stumbled over words | | |
| 16. Masculine | | |
| 17. Anxious | | |
| 18. Strong posture | | |
| 19. Hesitant | | |

# Results

### Leadership and Followership Ratings

Inter-rater reliability for single items was reasonable (alpha = .80, averaged across all items). First, I averaged across all raters to come up with an average score for each item. Then I conducted a principal components analysis on the leader items. This analysis revealed that a one-factor solution fit the data. I reversed scored all items that loaded negatively onto the factors (items 2, 6, 11, 14, 15, 17, and 19). Then, I averaged across all leader items, which created an overall index of Leadership behavior.

I then conducted a principal components analysis on the follower items. This analysis revealed that a two-factor solution fit the data. Table 9 includes the factors onto which each item loaded. The first factor included items 1, 2, 3, 4, 5, 7, 8, 9, 10, and 11, which I called the Followership factor. The second factor included items 6, 12, and 13, which I called the Communication factor because it included items associated with the follower's communication behavior with the leader. To create an index of Followership, I reversed scored items 2 and 11 because they negatively loaded onto Factor 1. Then I averaged across all items that loaded on the first factor, which yielded an index of Followership behavior. I was not interested in communication behavior, and thus, I did not include the second factor in any of the analyses below.

**Initial Analyses**

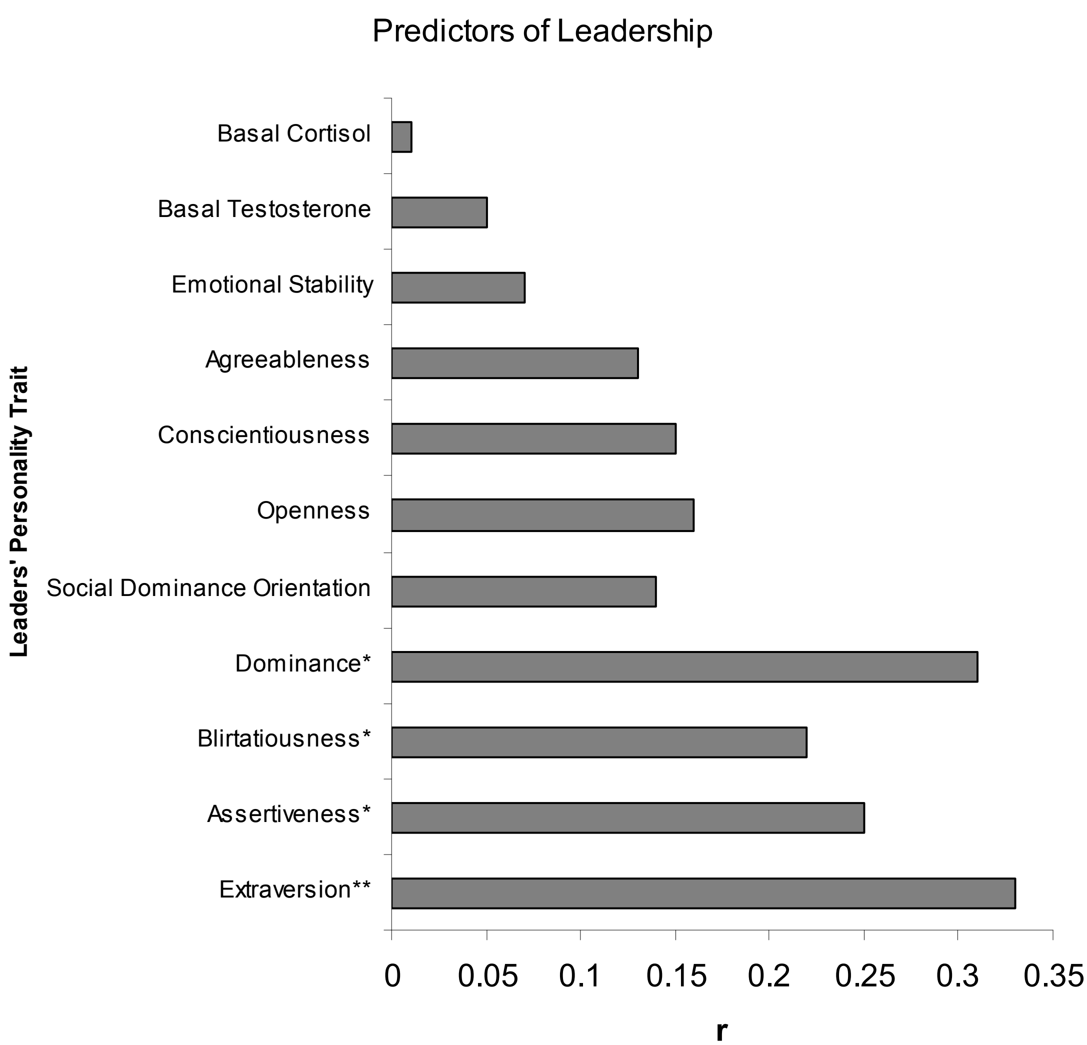
There was a moderate correlation between the Leadership and Followership behaviors, $r = .39$, $p < .01$. Leadership behaviors were associated with quicker block design performance, $r = -.43$, $p < .01$, but Followership behaviors were unrelated to performance, $r = -.15$, $p > .10$.

**Personality, Hormones, and Leadership Behaviors**

Figure 2 shows which of the leader's individual difference variables predicted Leadership behavior. As shown, self-reported extraversion, dominance, assertiveness, and blirtatiousness were all associated with the Leadership index. Neither testosterone nor cortisol was associated with Leadership. When the time of the experiment was controlled for, testosterone and cortisol were still unrelated to Leadership, p's > .60.

I next tested whether the significant relationships found between self-reported personality and Leadership would hold up when controlling for performance. Partial correlations revealed that extraversion, dominance, assertiveness, and blirtatiousness still predicted Leadership when controlling for performance, p's < .05. Similarly, these relationships remained significant when controlling for Followership behaviors, p's < .05.

*Figure 2. Correlations between individual difference variables and Leadership behavior*

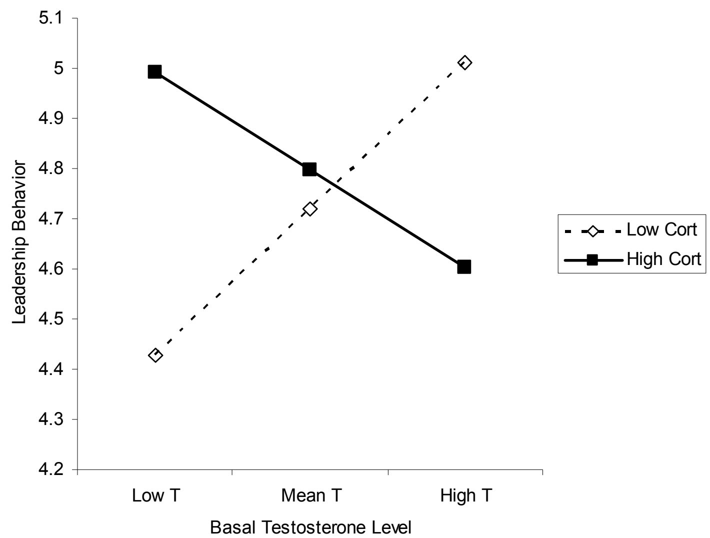



†p< .10, *p< .05, **p < .01

I next tested whether testosterone and cortisol might interact to predict Leadership behaviors. A hierarchical multiple regression model with the time of the experiment as a covariate found a statistically significant testosterone x cortisol interaction on Leadership behaviors, R-squared change = 6.4%, $F(1, 85) = 5.83$, $p < .02$. The gender x basal testosterone x basal cortisol three-way interaction was not statistically significant, $F(1, 81) = .38$, $p > .50$. In order to interpret basal testosterone x basal cortisol interaction, the Leadership scores were plotted at the basal testosterone and basal cortisol means, as well as one standard deviation above and below these means for both testosterone and cortisol. As shown in Figure 3, individuals <u>high</u> in testosterone and <u>low</u> in cortisol were high in Leadership behaviors, whereas individuals <u>low</u> in testosterone and <u>low</u> in cortisol were low in Leadership behaviors. Even though the basal testosterone x basal cortisol interactions were not statistically significant when the data were analyzed for each sex individually (p's > .10), Figure 3 also depicts the pattern of data for men and women separately.

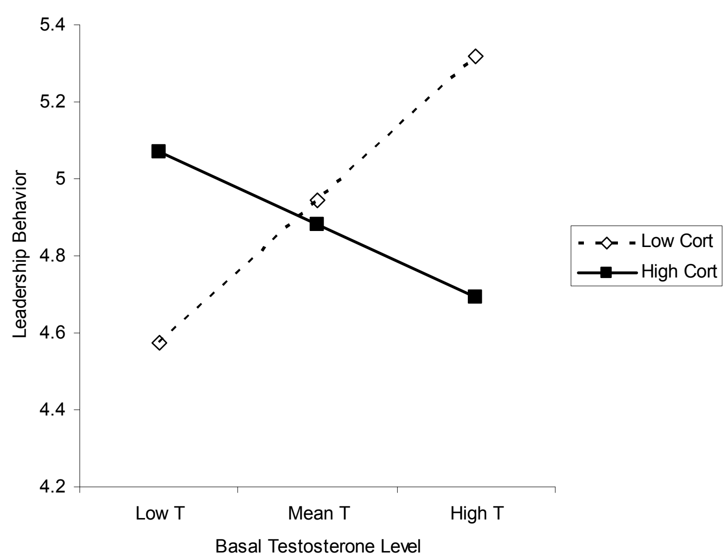
*Figure 3. Leadership behavior as a function of basal testosterone and basal cortisol.*

*Both sexes combined.*



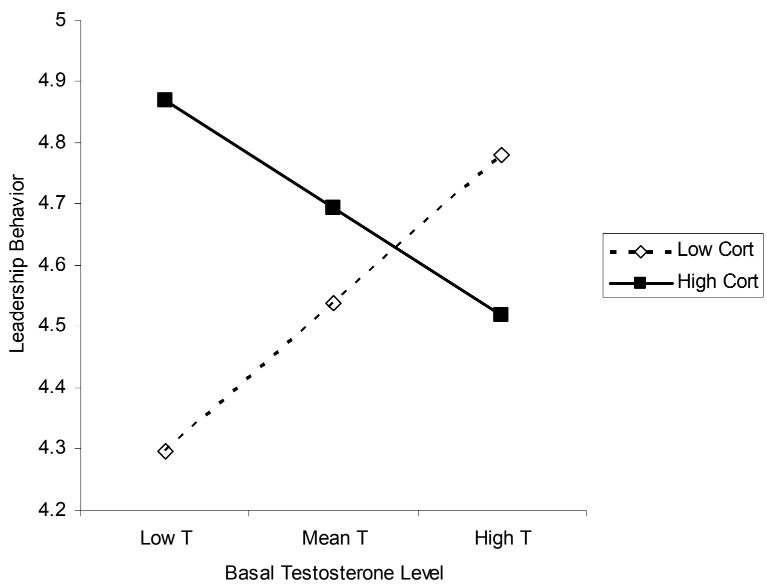

Note. T = testosterone, Cort = Cortisol. Low T = 1 SD below the standardized basal testosterone mean, High T = 1 SD above standardized basal testosterone mean. Low Cort = 1 SD below mean of log-transformed basal cortisol distribution. High Cort = 1 SD above mean of log-transformed basal cortisol distribution.

*Men Only.*



*(Figure 3 continued)*

*Women Only.*




I also examined whether the follower's personality traits were associated with the leader's behaviors. There were no statistically significant relationships for any of the follower's individual difference variables, p's > .10.

**Hormones versus self-reports as predictors of Leadership**

I next tested whether the testosterone x cortisol interaction would predict Leadership above and beyond self-reports. A series of hierarchical regressions were run in which self-reports, hormones, and the time of the experiment were entered as predictors of Leadership behavior in Step 1, and the testosterone x cortisol interaction was added to the model in Step 2. See Table 10. In all models, the testosterone x cortisol interaction was a statistically significant predictor of leadership behavior. Moreover, this interaction uniquely predicted leadership behaviors above and beyond self-reports, explaining an additional 5% of the variance.

**Personality, Hormones, and Followership Behavior**

There were no significant relationships between the follower's personality traits and the follower's behaviors using simple correlations. Testosterone, cortisol, and their interaction were also unrelated to follower behaviors, p's > .60. However, when Leadership behavior was controlled for, there was a significant partial correlation between the follower's extraversion and Followership behavior, $r = .25$, $p < .05$. None of the other individual difference variables were significant predictors of Followership.

Did any of the leader's individual difference variables predict the follower's behaviors? Yes, both the leader's conscientiousness and the leader's openness were positively associated with Followership ($r = .23$, $p < .05$ for conscientiousness, $r = .21$, $p < .05$ for openness). None of the other individual difference variables were related to Followership.

*Table 10. Hierarchical Regressions of Self-Reports and Hormones Predicting Leadership Behaviors*

| | Standardized Beta | t | $R^2$ change | F change |
|---|---|---|---|---|
| **Model 1** | | | | |
| **Step 1** | | | .11 | 2.75* |
| 1. Time of Experiment | -.01 | -0.10 | | |
| 2. Extraversion | .32 | 3.11** | | |
| 3. Basal Testosterone | -.13 | -.1.04 | | |
| 4. Basal Cortisol | .07 | 0.66 | | |
| **Step 2** | | | .05 | 5.15* |
| 5. Cortisol x Testosterone | -.28 | -2.27* | | |
| **Model 2** | | | | |
| **Step 1** | | | .07 | 1.59 |
| 1. Time of Experiment | -.02 | -0.18 | | |
| 2. Assertiveness | .23 | 2.19* | | |
| 3. Basal Testosterone | -.15 | -1.14 | | |
| 4. Basal Cortisol | .01 | 0.13 | | |
| **Step 2** | | | .05 | 4.75* |
| 5. Cortisol x Testosterone | -.28 | -2.18* | | |
| **Model 3** | | | | |
| **Step 1** | | | .04 | 0.91 |
| 1. Time of Experiment | .01 | 0.13 | | |
| 2. Blirtatiousness | .17 | 1.52 | | |
| 3. Basal Testosterone | -.16 | -1.14 | | |
| 4. Basal Cortisol | .02 | 0.20 | | |
| **Step 2** | | | .05 | 4.86* |
| 5. Cortisol x Testosterone | -.29 | -2.20* | | |

(con't on next page)

†$p < .10$, *$p < .05$, **$p < .01$

*Table 10 (con't). Hierarchical Regressions of Self-Reports and Hormones Predicting Leadership Behaviors*

| | Standardized Beta | t | $R^2$ change | F change |
|---|---|---|---|---|
| **Model 4** | | | | |
| **Step 1** | | | .10 | 2.32† |
| 1. Time of Experiment | -.02 | -0.17 | | |
| 2. Dominance | .28 | 2.75** | | |
| 3. Basal Testosterone | -.13 | -1.01 | | |
| 4. Basal Cortisol | .02 | 0.15 | | |
| **Step 2** | | | .05 | 4.71* |
| 5. Cortisol x Testosterone | -.27 | -2.17* | | |

†p< .10, *p< .05, **p < .01

## Discussion

Study 2 investigated whether basal hormones and self-reported personality traits predict social behaviors in leader-follower interactions. Consistent with previous research on personality and leadership (Judge et al., 2002), extraversion and its subfacets (dominance, assertiveness, and blirtatiousness) were all positively related to leadership behaviors (e.g., confident, decisive, comfortable, leader-like). These effects persisted even when task performance and follower behaviors were controlled for.

This study extended previous work by demonstrating for the first time that an interaction between basal testosterone and basal cortisol also predicts leadership behavior. Individuals high in testosterone and low in cortisol were perceived as strong leaders (e.g., dominant, confident, leader-like), whereas individuals low in testosterone and low in cortisol were perceived to be poorer leaders (e.g., nervous, hesistant). Importantly, this interaction uniquely predicted leadership behaviors above and beyond self-reported extraversion, assertiveness, dominance, and assertiveness. Thus, it seems that endocrine systems exert independent effects on leadership that are separate from the effects of self-reported personality traits on leadership. The testosterone-cortisol interaction is consistent with previous research, which found that high testosterone coupled with low cortisol was associated with greater aggression (Popma et al, 2007). However, this previous research only demonstrated a testosterone-cortisol interaction on anti-social behaviors (aggression), but the present study found evidence that this interaction could also predict important prosocial behaviors (leadership). The results of the present study also dovetail nicely with the results of Study 1, which found that high testosterone coupled with low cortisol predicted high levels of implicit power motive.

Taken together, these studies suggest that individuals high in testosterone and low in cortisol show high power motive and strong leadership, whereas individuals low in testosterone and low in cortisol show low power motive and poorer leadership.

Inconsistent with our expectations, however, the interaction showed symmetry such that low testosterone coupled with high cortisol also exhibited strong leadership. So why might this be the case? It could be that among low testosterone individuals, high cortisol represents arousal and approach motivation which led to good leadership, whereas among high testosterone individuals, high cortisol may represent stress and anxiety, which may have led to poorer leadership. This explanation can be tested in future research.

There were some limitations to the current study. First, a cognitive task taken from an intelligence test (the WAIS-III, Weschler, 1997) was used to investigate leader and follower behaviors. As a result, it is likely that intelligence played a strong role on this task. The block design task was certainly useful in that it allowed us to examine social behaviors of interest in the current study. But it would also be important to replicate these effects using a non-cognitive task in which intelligence does not play as strong a role (e.g., the leaderless discussion group, cf. Hogan & Kaiser, 2005).

Second, the task used dyads, but leadership in the real world usually involves groups. Future studies should attempt to replicate these effects using groups. Third, only one saliva sample was taken from each participant, which provided a measure of basal cortisol and basal testosterone. But future studies should attempt to collect multiple samples, which would allow for examination of task-related hormonal changes. Finally, some researchers may question the ecological validity of this study because it was conducted in a laboratory setting. But it may be possible to conduct a similar study using real-world leaders. Hormone samples could be taken from various leaders (e.g., managers, CEOs), and ratings of leadership and followership could be collected from others who work with them (e.g., subordinate ratings). If the findings from the current study generalize, then leaders who have high testosterone and low cortisol should receive high leadership ratings, whereas individuals who have low cortisol and low testosterone should receive low leadership ratings.

# STUDY 3: HORMONES AND SOCIAL DECISION MAKING IN THE HAWK-DOVE GAME

## Overview

Study 2 investigated the relationship between basal testosterone and social behaviors in leader-follower interactions – one important context in which social status is relevant. The present study (Study 3) and the one following it (Study 4) test whether basal testosterone predicts social behaviors in another status-relevant social context: economic social interactions. Although some research has begun to understand how self-reported personality traits affect economic social behavior, few empirical studies to date have investigated whether hormone levels can explain behavior in economic contexts. The present study tested whether basal hormones, self-reported personality traits, and implicit motives predict social decisions in dyadic economic interactions. This research, coupled with other research on the biological correlates of economic behavior (e.g., neuroeconomics research, Rilling et al., 2007) has the potential to greatly increase our understanding of the biological systems associated with social decision making.

## Background

Individuals often conflict with one another when deciding how to distribute limited resources. Corporate executives might squabble over how much of the company's limited funds to allocate to each of the company's subdivisions. Politicians might be in disagreement over what proportion of government revenue to spend on various government programs. And even two business partners might be at odds over how much of the money from the latest sale each individual should pocket. Such social conflicts tend to involve mixed motives to compete or to cooperate. On the one hand, each individual will want to pursue his or her own selfish interests and take as much of the limited resource as possible. But on the other hand, if all group members were to pursue selfish interests, fierce competition might ensue, and most individuals could end up worse off than if they had instead decided to cooperate. Thus, each individual may be faced with a difficult dilemma – should I compete with others to pursue my own selfish interests and to gain or maintain status over others, or should I cooperate with others to ensure the best collective outcome? What predicts how individuals behave in these situations?

One particular paradigm used in the behavioral economics literature that is especially relevant to research on social conflicts is the Hawk-Dove game (e.g., Matsumura & Kobayashi, 1998; Wit & Wilke, 1992), also known as the Chicken Game. This game is a variant of the more well-known Prisoner's Dilemma. In both the Prisoner's Dilemma and the Hawk-Dove Game, there are two players. In each round of the game, players make a decision to cooperate or defect. Figure 4 shows equivalent payoff matrices for the Hawk-Dove Game. The Prisoner's Dilemma is also shown for comparison. In both games, if both players make the cooperative choice (Choice A), then each player is paid \$2. The games differ in each of the remaining quadrants of the matrix. In the Hawk-Dove game, if both players defect, then neither player is paid anything. But if one player defects and the other cooperates, then the individual who defected is paid \$4, while the individual who cooperated is paid \$1. Compared to the Prisoner's Dilemma, there is a greater incentive to cooperate in the Hawk-Dove game if one expects the other player to defect. As a result, this game is thought to model social dominance (Matsumura & Kobayashi, 1998). Presumably, a hawk will continue to "fight" (defect), even if the other player does not back down. On the other hand, a dove will “retreat” (cooperate) rather than engage in an all-out fight.

*Figure 4. Payoff Matrices for the Prisoner's Dilemma and the Hawk-Dove Game. Dollar amounts in bold awarded to Player A. Dollar amounts in parentheses awarded to Player B.*

## <u>Prisoner's Dilemma</u>

| | | Player A | |
|---|---|---|---|
| | | **Cooperate** | **Defect** |
| **Player B** | **Cooperate** | **\$2**(2) | **\$4**(0) |
| | **Defect** | **\$0**(4) | **\$1**(1) |

## <u>Hawk-Dove Game</u>

| | | Player A | |
|---|---|---|---|
| | | **Cooperate** | **Defect** |
| **Player B** | **Cooperate** | **\$2**(2) | **\$4**(1) |
| | **Defect** | **\$1**(4) | **\$0**(0) |

Some studies have already examined the personality traits associated with economic decisions in the Prisoner's Dilemma. For example, individuals high in psychopathy (Rilling et al., 2007) and high in competitiveness (Houston et al., 2000) tend to defect more, whereas individuals with an internal locus of control, individuals high in self-monitoring, and individuals high in sensation-seeking tend to cooperate more (Boone et al., 1999). Using different games, other studies have uncovered the endocrine systems that influence social decision making. For example, researchers using the Trust Game have demonstrated that experimentally-induced rises in oxytocin increase economic decisions indicative of trust (Kosfield et al., 2005). However, no studies to my knowledge have examined the personality traits or hormones associated with economic decisions in the Hawk-Dove game.

As review in Chapter 1, individual differences in basal testosterone may be associated with dominance, particular under conditions of social competition (e.g., Wingfield et al., 1990). Therefore, it seems plausible that basal testosterone may underlie decisions to cooperate or defect in the Hawk-Dove game such high testosterone individuals will be more likely to defect in this game relative to low testosterone individuals. However, another possibility based on previous research (e.g., Popma et al., 2007) as well as the results from previous chapters, is that testosterone and cortisol will interact to predict economic decisions, such that individuals high in testosterone and low in cortisol will be most likely to defect in this game. This hypothesis will also be tested. A second goal is to test whether the relationship between basal T and economic decisions depends on the decisions of the other players. Therefore, I will examine whether the interaction between basal T and the other player's behavior predicts economic decisions.

A third goal of the present study is to compare the predictive validity of basal hormones with the predictive validity of self-reports and implicit motives. For example, if testosterone predicts economic decisions, does it predict these decisions above and beyond self-reported dominance or the implicit power motive?

**Study 3 Overview**

In the present study, participants provided self-reports of personality traits and wrote creative stories in response to picture cues. These stories were later coded for implicit power, affiliation, and achievement motives. Then participants played the Hawk-Dove Game against a same-sex player over multiple rounds, providing saliva samples, before, during, and after the game. Based on the previous literature on testosterone and dominance, I hypothesized that high testosterone individuals would defect more than low testosterone individuals, and that this effect would be independent of any effects of self-reported personality or implicit motives.

## Method

**Participants**

98 University of Texas at Austin students (42 men) took part in a study of economic decision making, hormones, and personality. Participants were paid according to their earnings during the Chicken Game. The average payment was $16.50.

**Procedure**

Participants completed online self-reports and an online version of the Picture Story Exercise prior to reporting to the lab. The personality constructs that were measured using these techniques are shown in Table 2.

Participants reported to the lab in same-sex pairs between 11:00 AM and 5:30 PM to minimize the effects of circadian fluctuations in T and cortisol levels (Touitou and

Haus, 2000). The experimenter led each participant to a separate room, obtained informed consent, and collected the first saliva sample. The samples were immediately brought to a nearby freezer for storage and were later analyzed for T and cortisol concentrations using radio immunoassay. After providing the first saliva sample, participants were explained that they would be playing with the other participant in an economic decision making task. Participants were explained the Hawk-Dove Game, and then played 5 rounds of the game. Each participant sat in individual rooms while they played the game. They made their decision and placed their choice (a card with the letter "A" on it or a card with the letter "B" on it) in an envelope and handed their envelope to the experimenter. The experimenter collected each participant's decision and determined how much money each participant earned. The experimenter then placed a piece of paper in each participant's envelope indicating how much he or she earned and handed the envelope back to each participant. This process was repeated for 5 rounds. Participants were asked to track their choices and how much money they earned on a tracking sheet. After five rounds of the game, the experimenter recorded how long the five rounds of the game took. Then participants filled out a short questionnaire, which included items such as "I enjoyed the five rounds of the game." and "I am satisfied with how much I earned in the game so far." They indicated their agreement/disagreement with these items on a 7-point scale (1 = Strongly disagree, 7 = strongly agree). After that, participants provided a second saliva sample, then played five more rounds of the game with the same participant. Participants filled out another short questionnaire including similar items as the first questionnaire and provided a third saliva sample. Then participants were debriefed and paid in cash based on what they earned during the game.

# Results

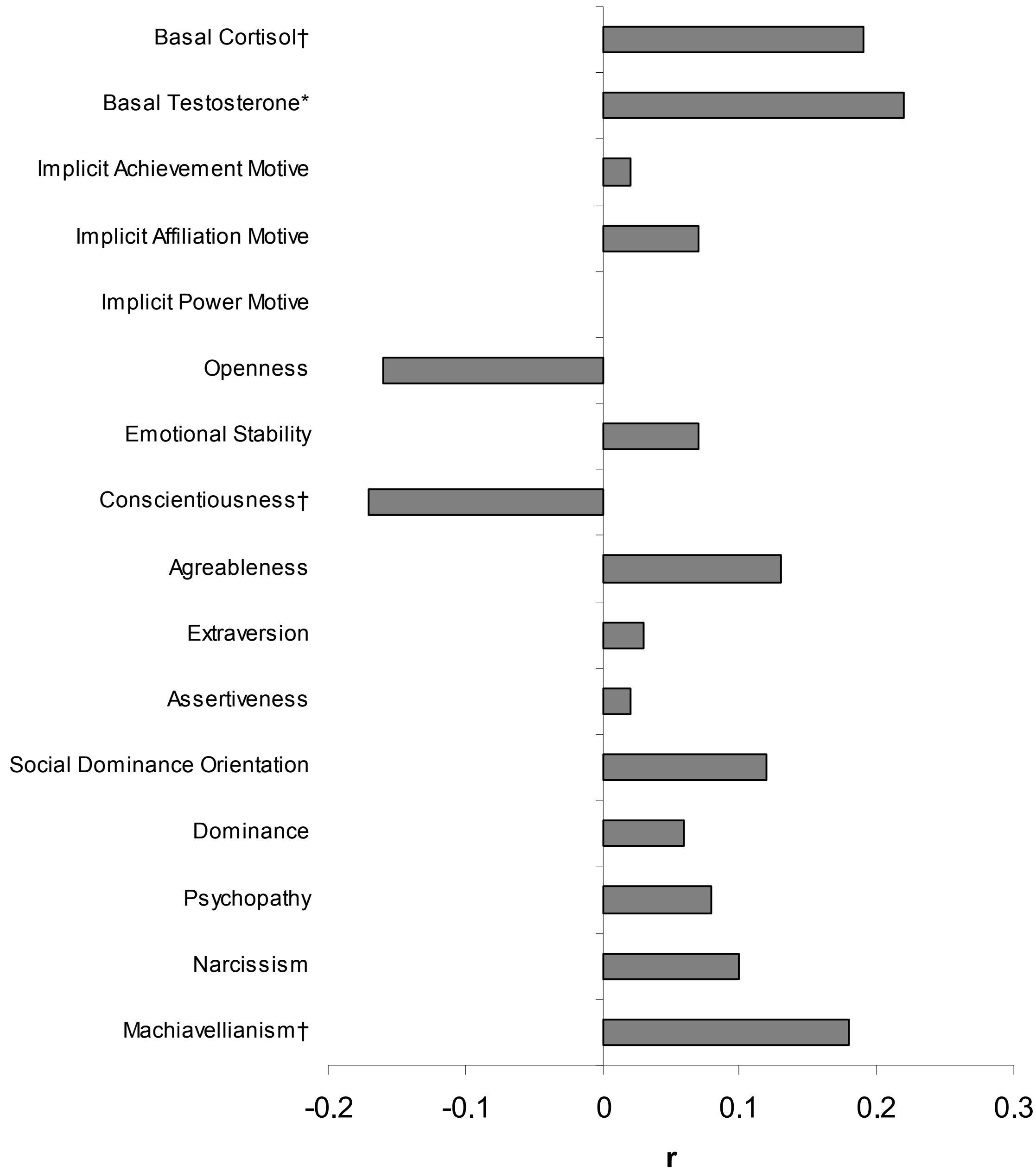
## Initial Analyses

Economic decisions were aggregated by summing the total number of defections per participant across all 10 rounds of the game. Across all 10 rounds, participants defected an average of 5.3 times (SD = 2.1). There was no sex difference in the number of defections, $t(98) = 0.5$, $p > .10$.

## Predictors of Economic Decisions

The number of defections was correlated with the number of defection made by one's partner, $r = .64$, $p < .01$. Therefore, partial correlations between individual differences variables (self-reported personality, implicit motives, basal hormones) and decisions were conducted using one's partner's choices as a covariate. Basal hormones levels used the additional factor of the time of the experiment as a covariate. Figure 5 shows these partial correlations. These analyses revealed that basal testosterone was a statistically significant predictor of economic decisions such that high testosterone individuals were more likely to defect than low testosterone individuals. Basal cortisol and Machiavellianism and were also positively associated with defection, but these relationships were marginally significant, $p < .10$. In addition, conscientiousness was negatively associated with defection, but this effect was also marginally significant, $p < .10$.

*Figure 5. Partial correlations between individual difference variables and number of defections in the Hawk-Dove Game, controlling for number of defections made by one's partner.*




†p< .10, *p< .05, **p < .01

Note. Basal testosterone and basal cortisol were measured from the first saliva sample. Partial correlations for these two hormones also controlled for the time of the experiment.

I also tested whether the interaction between basal testosterone and cortisol would predict economic decisions. To do so, the following variables were entered as predictors of the number of defections in a multiple regression: time of the experiment, the number of defections made by one's partner, basal testosterone, basal cortisol, and the basal testosterone x basal cortisol interaction. This model revealed a non-significant interaction term, $p > .20$.

I nexted whether fluctuations in hormone levels over the course of the study were associated with economic decisions. Change in testosterone was calculated as the unstandardized residuals of a regression analysis with standardized time 1 testosterone as the predictor and standardized time 3 testosterone as the dependent variable. Change in cortisol was calculated as the unstandardized residuals of a regression analysis with log-transformed time 1 cortisol as the predictor and log-transformed time 3 cortisol the dependent variable. Correlational analyses revealed that change in testosterone was unrelated to economic decisions, $r = -.07$. However, change in cortisol did show a statistically significant negative correlation with the number of defections, $r = -.20$, $p < .05$, indicating that individuals who rose in cortisol during the study tended to make cooperative decisions, whereas individuals who dropped in cortisol tended to defect more.

**Hormones versus other predictors of economic decisions**

I next tested whether basal testosterone would predict economic decisions above and beyond basal cortisol, conscientiousness and Machiavellianism, which were all marginally significant predictors of decisions. Three multiple regressions were run in which basal testosterone, the time of the experiment, and the number of defections made by one's partner were entered as predictors of the number of defections, along with each of the marginally significant predictors entered individually. See Table 11. In all three models, basal testosterone was still a statistically significant predictor of decisions. Basal cortisol and conscientiousness were still marginally significant predictors, but Machiavellianism was no longer significant in this model. A fourth model showed that change in cortisol predicted decisions even when controlling for change in testosterone. Overall, these analyses reveal that basal testosterone predicted cooperate-defect decisions in the Hawk-Dove Game above and beyond basal cortisol and above and beyond self-reports. In addition, change in cortisol predicted cooperate-defect decisions above and beyond change in testosterone.

*Table 11. Multiple Regressions of Self-Reports and Hormones Predicting Number of Defections*

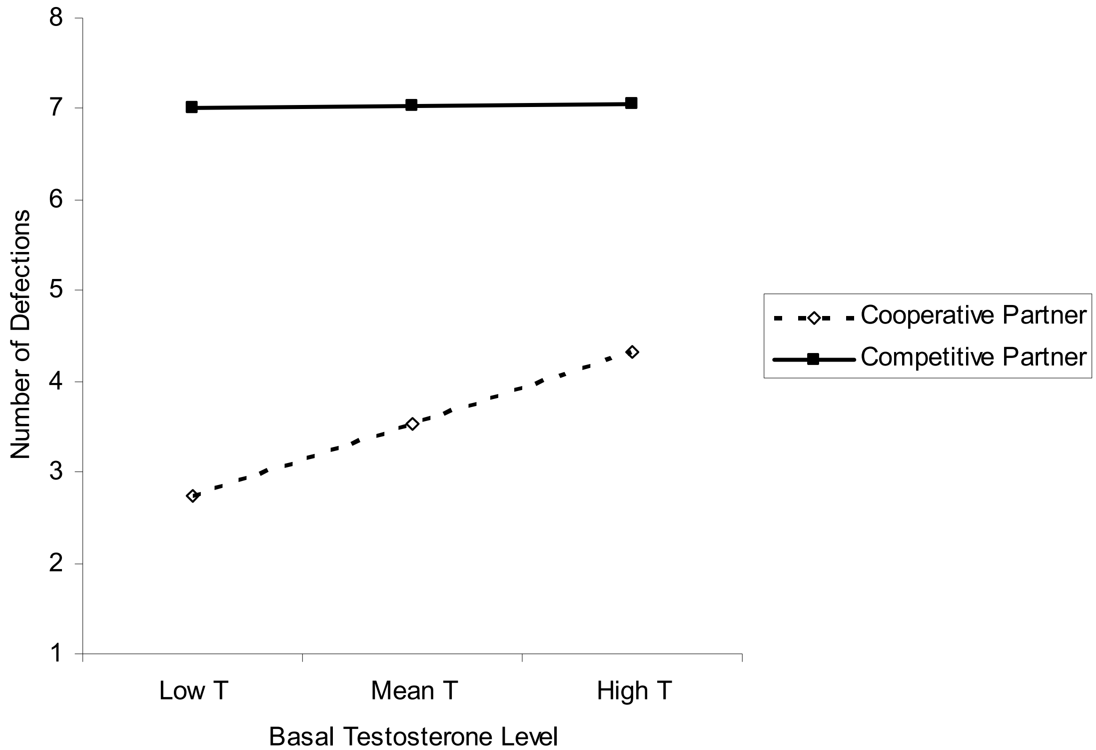
| | Standardized Beta | t | p-value | R-squared |
|---|---|---|---|---|
| **Model 1** | | | | |
| 1. Time of Experiment | .07 | 0.92 | .36 | |
| 2. Partner's number of Defections | .64 | 8.24 | .00** | |
| 3. Basal Testosterone | .16 | 2.00 | .048* | |
| 4. Basal Cortisol | .15 | 1.88 | .06† | |
| Overall Model | | | .00** | .47 |
| **Model 2** | | | | |
| 1. Time of Experiment | .04 | 0.54 | .59 | |
| 2. Partner's number of Defections | .63 | 8.11 | .00** | |
| 3. Basal Testosterone | .19 | 2.41 | .02* | |
| 4. Conscientiousness | -.14 | -1.75 | .08† | |
| Overall Model | | | .00** | .47 |
| **Model 3** | | | | |
| 1. Time of Experiment | .03 | 0.36 | .72 | |
| 2. Partner's number of Defections | .64 | 8.13 | .00** | |
| 3. Basal Testosterone | .18 | 2.27 | .03* | |
| 4. Machiavellianism | .13 | 1.60 | .11 | |
| Overall Model | | | .00** | .46 |
| **Model 4** | | | | |
| 1. Time of Experiment | .02 | 0.24 | .81 | |
| 2. Partner's number of Defections | .63 | 8.01 | .00** | |
| 3. Change in Testosterone | -.04 | 0.50 | .62 | |
| 4. Change in Cortisol | -.18 | 2.11 | .04* | |
| Overall Model | | | .00** | .42 |

†p< .10, *p< .05, **p < .01

**Interaction Between Basal Testosterone and Opponent's Behavior**

The above analyses showed that basal testosterone predicted economic decisions, controlling for the other player's decisions. But might the relationship between basal testosterone and decisions depend on whether the other player was cooperative or competitive? I tested this possibility using a multiple regression model in which the number of defections an individual made was entered as the dependent variable and the following variables were entered as predictors: time of experiment, partner's number of defections, basal testosterone, and the basal testosterone x partner's defections interaction. This model revealed two main effects and a statistically significant interaction term $t(98) = 2.04$, $p < .05$. To interpret this interaction, I plotted the total number of defections an individual made as a function of basal T (low T = one standard deviation below the mean, mean T = at the mean; high T = one standard deviation above the mean) and as a function of the partner's total number of defections (cooperative partner = 1 standard deviation below the mean, competitive partner = 1 standard deviation above the mean). See Figure 6. As shown, high T individuals defected more than low T individuals only when playing against a cooperative player. When playing against a competitive player, low and high T individuals tended to defect at about the same rate.

*Figure 6. Number of defections in the Hawk-Dove Game as a function of basal testosterone and partner behavior.*



## Discussion

The present study demonstrates that basal testosterone predicts economic decisions in the Hawk-Dove Game. High testosterone individuals were more likely to defect in the game than low testosterone individuals. This effect held even when other variables were controlled for, including the time of the experiment, one's partner's choices, basal cortisol, and self-reported personality (conscientiousness, Machiavellianism). The main effect of basal testosterone on decisions, however, was superseded by an interaction with the partner's behavior. When playing against a <u>cooperative</u> partner, high T individuals were more likely to defect than low T individuals. When playing against a <u>competitive</u> partner, basal T no longer predicted decisions. Presumably, individuals high in testosterone are motivated to gain status, which leads them to exploit cooperative partners as a strategy to achieve higher status. Conversely, individuals low in testosterone may be motivated to cooperate and avoid high status, which leads them to respond to cooperation with more cooperation. This interpretation is consistent with previous research, which has found that basal testosterone predicts dominance/submission motivation in competitive as well as cooperative social settings (Josephs et al., 2003; 2006; Newman et al., 2005; Mehta et al., under review; Mehta, Wuerrhman, & Josephs, in prep).

This study also revealed that change in cortisol was a statistically significant predictor of economic decisions. Individuals who rose in cortisol throughout the study were more likely to exhibit cooperative decisions, whereas individuals who dropped in cortisol were more likely to defect. This finding is consistent with research suggesting that elevated cortisol is associated with behavioral inhibition (Kagan et al., 1987; Smider et al., 2002), and lower cortisol is associated with aggression and approach motivation (Shoal et al., 2003; Virgin & Sapolsky, 1997). It is possible that change in cortisol had a causal influence on cooperate-defect decisions, but given the correlational nature of this finding, the direction of effect could be the other way around (e.g., defection leads to drops in cortisol) or a third variable may explain both cortisol change and economic decisions. However, future research should still consider the possibility that fluctuations in cortisol do have a meaningful influence on subsequent economic decisions. Studies in which cortisol is exogenously administrated can more directly test this hypothesis.

The primary limitation of this study was that it did not control for the other player's decisions; instead, dyads interacted naturally. This was certainly a good strategy for an initial study, but a follow-up study should attempt to replicate the testosterone x partner behavior interaction using an experimental design (e.g., random assignment to a competitive or cooperative "partner" who in actuality is a confederate). Such a study would be important to confirm that high and low testosterone individuals do indeed react differently to cooperative behaviors.

Nevertheless, this study provides the first empirical connection between testosterone, cortisol, and behavior in economic decision making interactions. Although behavioral economists have investigated the neural systems underlying economic decisions (e.g, Sanfey et al., 2003), researchers have paid much less attention to the hormones involved in these decisions. This study, together with previous research on the role of oxytocin in the Trust Game (Kosfield et al., 2005), suggest that endocrine systems do play an important role in economic social interactions.

## STUDY 4: HORMONES AND SOCIAL DECISION MAKING IN THE ULTIMATUM AND THIRD PARTY PUNISHMENT GAMES

### Overview

Study 2 tested the relationship between basal hormones and behavior in leader-follower interactions, and Study 3 tested the relationship between hormones and behavior in one particular behavioral economics paradigm: the Hawk-Dove Game. In the present study, I examine testosterone and social decision making in two other economic tasks that are relevant to research on dominance: the Ultimatum and the Third Party Punishment games (Henrich et al., 2006). Although the emerging field of neuroeconomics has begun to investigate the neural systems underlying decisions in these paradigms (e.g., Ultimatum Game, Sanfey et al., 2003), *no* empirical studies have yet to investigate whether hormones are related to behavior in these games. Thus, the present study has the potential to greatly inform theoretical models of the biological roots of economic social behavior. Past research provides evidence that decisions in these paradigms are, at least in part, motivated by a desire to gain or maintain high status. Therefore, I will use these games to investigate whether basal testosterone predicts dominant decisions in response to a status threat.

Furthermore, very little attention has been devoted to personality constructs that might be associated with decisions in these games. Thus, incorporating measures of personality into the study of these games has the potential to increase our theoretical understanding of the personality constructs that are associated with economic decisions.

**Ultimatum Game**

In the Ultimatum Game (Henrich et al., 2006), two players – a proposer and a responder – are given the opportunity to share a fixed sum of money, called the stake. The proposer first makes an offer to the responder as to how he or should would like to split the stake. The responder can either accept or reject this offer. If the responder accepts the offer, the stake is split as proposed. But if the responder rejects the offer, then neither player receives any money. Once the responder makes a decision, the game is over.

Research that has manipulated proposers' offers in the Ultimatum Game demonstrates that about half of responders reject low offers from human partners (about 20% of the stake, Henrich et al., 2006). Interestingly, low offers from computer partners are rejected much less often that low offers from human partners (Sanfey et al., 2003). Additional studies provide compelling evidence that the motivation to reassert status over the proposer underlies the rejection of low offers from human partners. Indeed, individuals report rejecting low offers because they perceive such offers as unfair and experience anger (Pillutla et al., 1996). Further, individuals who subsequently reject low offers experience greater activation in the anterior insula – a brain area associated with negative emotion (Sanfey et al., 2003), and greater skin conductance (van 't Wout et al., 2006) The connection between rejection of low offers and reasserting status is also consistent with economic evolutionary analysis, which suggests that a concern for reputation motivates the rejection of low offers in the Ultimatum Game (Nowak et al., 2000). Taken together, theory and research indicate that low offers in the Ultimatum

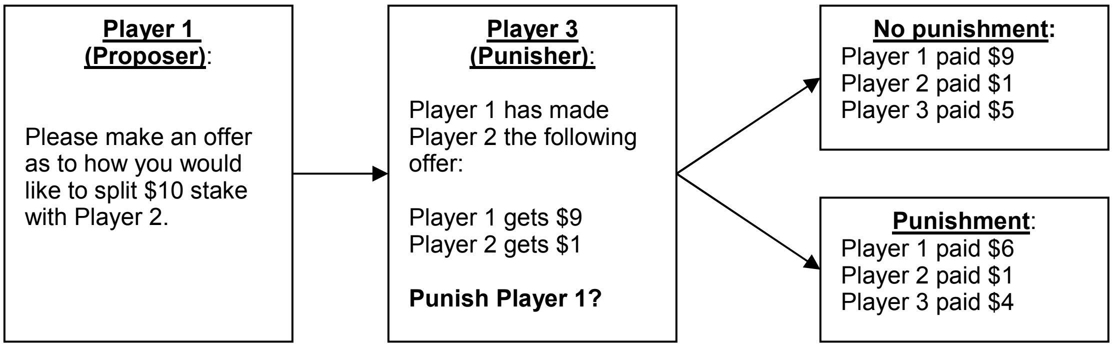
Game are perceived by some individuals as a threat to their social status, which in turn, drives these individuals to reject low offers in order to protect their social status.

Because past research -- as reviewed in Chapter 1 -- suggests that basal testosterone may be related to dominance, I predict that high T individuals will be more likely than low T individuals to reject low offers in this game as a strategy to gain or maintain high status. Further, because little to no research has investigated whether personality constructs predict decisions in this game, I will also investigate the relationships between self-reported personality and decisions in the Ultimatum Game. Taken together, this study has the potential to shed light on the key individual difference variables that underlie decisions in this paradigm.

**Third Party Punishment Game**

Dominance is also relevant in the Third Party Punishment Game (Henrich et al., 2006). In this game (see Figure 7 below), Player 1 and Player 2 are to split a stake, and Player 1 proposes how to make the split. In the Third Party Punishment Game, however, Player 2 does not make any decisions. Instead, Player 3 – a third party individual– decides whether or not to punish player 1. If Player 3 chooses not to punish Player 1, then Player 1 and 2 split the stake as proposed, and Player 3 is paid half of the stake. But if Player 3 chooses to punish Player 1, then Player 3 loses 10% of the stake from his or her allocation but deducts 30% of the stake from Player 1's allocation. See Figure 7 below for an example involving a $10 stake.

*Figure 7. Schematic of the Third Party Punishment Game*




Similar to the Ultimatum Game, some third party Player 3's tend to punish Player 1 for making a low offer (Henrich.et al., 2006). Such third party punishment may also be motivated by a concern for status. That is, some third parties likely perceive a low offer from Player 1 as a threat to their own social status; after all, in the example above, Player 1 in the absence of punishment would overwhelmingly get the highest payout out of all three players and could be perceived to have "won" the game. Thus, punishment for these individuals will serve to "even out" the relative pay-offs between Player 1 and Player 3, and as a result, serve to protect Player 3's social status. Because the biological correlates of behavior have not been studied in this game nor have other individual difference variables (e.g., personality measures), it is unclear whether similar or different biological systems underlie dominance when an individual is a second party punisher, as in the Ultimatum Game, or a third party punisher, as in the Third Party Punishment Game. This question is of interest in the proposed study. Therefore, I will also examine whether basal testosterone predicts decisions in this game, and compare the predictive validity of basal T in the Ultimatum Game to the predictive validity of basal T in the Third Party

Punishment Game. Besides examining basal T as a predictor of decisions in these two games, I will also examine whether self-reports predict decisions.

**Study 4 Overview**

The primary goal of this study is to investigate whether basal testosterone predicts economic decisions in the Ultimatum and Third Party Punishment Games. Specifically, this study will test whether basal testosterone predicts rejection of low offers in the Ultimatum Game, and punishment of low offers in the Third Party Punishment Game. I will also examine whether basal testosterone predicts economic decisions above and beyond self-reported personality.

A second goal of this study is to examine fluctuations in testosterone. According to the reciprocal model, status-relevant social interactions should cause testosterone levels to fluctuate (Mazur & Booth, 1998). These fluctuations in testosterone should, in turn, encourage or discourage subsequent dominant behaviors (Mehta & Josephs, 2006). Previous research suggests that changes in testosterone during competitive interactions depend on personality (e.g. Schultheiss et al., 2005). Therefore, I will examine two questions: (1) Which personality variables predict fluctuations in testosterone? and (2) Are fluctuations in testosterone associated with decisions to punish low offers?

In this study, participants first played the Ultimatum Game in the role of responder, and then played the Third Party Punishment Game in the role of Player 3. The games were played in several one-shot interactions against other “players” via a computer interface. In reality, participants did not actually play with others; instead, the computer was programmed so that about half of the offers presented to participants were low, and the other half were equal split offers. The Ultimatum Game had a 2 (computer partner vs. human partner) x 2 (low offers vs. even split offers) within-subjects design. In the Third Party Punishment Game, there were no computer partners. All interactions were ostensibly with others humans in a one-factor (low offers vs. even split offers) within-subjects design.

## Method

### Participants

One hundred fifteen participants (54 men) participated in this study. Participants were Austin community members and UT students, recruited via craigslist.org and via campus fliers. In order to ensure a somewhat homogenous sample in terms of age, only participants between the ages of 18 and 30 were allowed to participate in the study. UT students were screened to ensure they had taken two or fewer courses in psychology or economics. Community participants were screened so that they had not majored in psychology or economics.

### Procedure

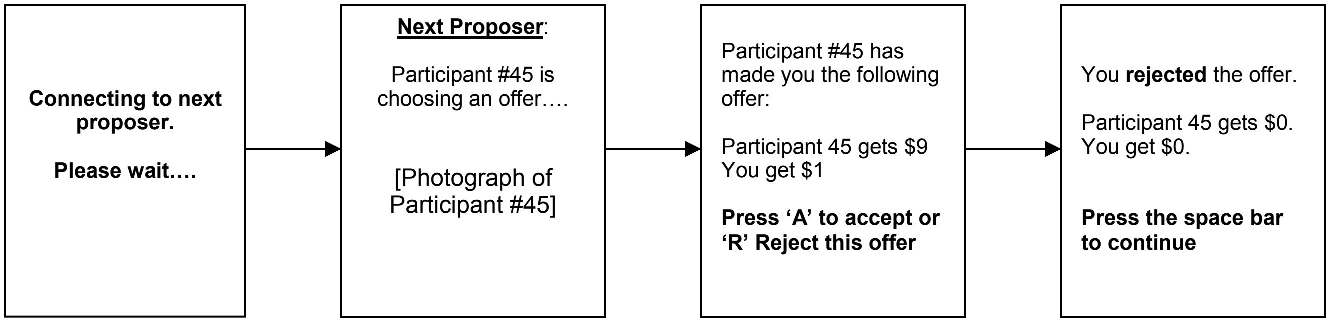
Participants completed several online self-report measures prior to reporting to the lab. The measures included are described in Table 2. As part of the online survey, participants were asked to provide at least one email address of an informant who could be contacted about the participant's personality.

After completing the online measures, participants reported to the lab at the Department of Psychology and were escorted to private lab rooms adjacent to one another. Participants were run individually or in small groups of up to five participants at a time. First, participants filled out an informed consent, and were explained that they would be participating in several economic tasks against other participants who were also in the lab. They were told that they were part of a large study at UT on economic social interactions, and that they would be interacting with others via an interactive computer program.

Participants then provided their first saliva sample by first chewing gum and then passively drooling approximately 2 mL of saliva into a polypropelene vial. The samples were immediately transported to a freezer for later immunoassay. Next, a digital face photograph of each participant was taken against the same background (a white wall). Participants were told that the purpose of the photograph was so participants in the study could see who they are interacting with in the computer program. Pilot testing revealed that this step is important in order to preserve credibility of the cover story.

Participants were told that they would next be playing with other participants in the laboratory on some economic tasks via a computer interface, and that they would be paid 10% of their earnings from the study. This compensation strategy has been used in previous research (van't vout et al., 2005). Participants played the Ultimatum Game first. For this game, participants were told that they would play one round at a time as responder with several other participants. It was emphasized that the partners would propose offers independently of one another, and would not be aware of the other proposers' offers. Additionally, it was indicated that participants would play against a computer partner in some rounds, and that the computer partner would randomly generate offers in these rounds. See Figure 8 for an example round against a human partner.

*Figure 8. Time line of a sample round in the Ultimatum Game against a human partner*




Participants played 30 rounds of the Ultimatum Game. Ten rounds were played against the computer, and 20 rounds against human partners. Opposite-sex social interactions involving status are likely to differ from same-sex ones. Therefore, to be consistent with my previous work on status and T in which only same-sex groups were studied (e.g., Josephs et al., 2006; Mehta & Josephs, 2006; Mehta et al., under review), only photographs of the same sex as the participant were presented. Each participant saw 5 $5:$5 offers, 1 $7:$3 offer, 2 $8:$2 offers, and 2 $9:$1offers from computer partners, and 7 $5:$5 offers, 4 $7:$3 offer, 6 $8:$2 offers, and 3 $9:$1offers from human partners. The photographs presented were chosen from a subset of participants who participated in a large pilot study during the Fall of 2006 who gave permission to use their photographs for research purposes. For computer rounds, a picture of a computer was shown. Participants indicated their decision to accept or reject offers by pressing A or R on their keyboard.

After completion of the Ultimatum Game, participants filled out a short questionnaire that assessed satisfaction and enjoyment of the game, along with affectivity (Watson, Clark, & Tellegen, 1988). After that, participants were explained the rules for the Third Party Punishment Game. In the Third Party Punishment Game, participants played 20 trials as Player 3. Each participant saw 8 \$5:\$5 offers, 5 \$6:\$4 offers, 3 \$7:\$3 offer, 2 \$8:\$2 offers, and 2 \$9:\$1offers from human partners. There were no computer partners in this game. In each round, two photographs were shown – one of Player 1 and the other of Player 2. The photographs were chosen from the same set of photographs used in the Ultimatum Game. Participants indicated their decisions by pressing P for punish and D for don't punish.

After this second game, participants filled out a second questionnaire assessing satisfaction and enjoyment of the game, along with affectivity. Participants then provided a second saliva sample. After this saliva sample, participants filled out another questionnaire in which they subjectively reported their reasons for accepting or rejecting offers, along with several items to check for suspicion in the study.

*Table 12. Descriptive Statistics for Economic decisions in the Ultimatum/Third Party Punishment Sample*

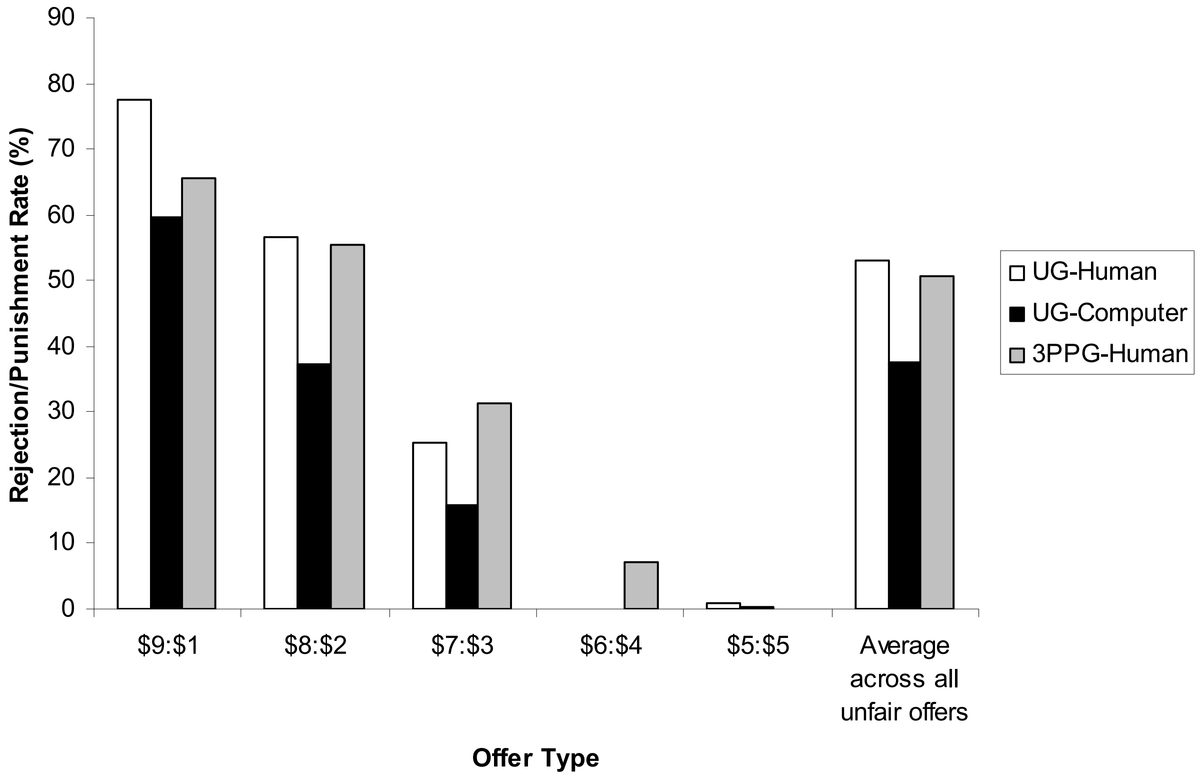
| | Men and Women (n = 115) | | Men (n = 54) | | Women (n = 61) | | Significant sex difference? |
|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD | t-statistic |
| **Economic Decisions** | | | | | | | |
| UG - Rejection rate of unfair offers from human partners (%) | 53.1 | 31.2 | 57.2 | 29.9 | 49.5 | 32.1 | 1.32 |
| UG - Rejection rate of unfair offers from computer partners (%) | 37.6 | 34.2 | 40.4 | 35.4 | 35.0 | 33.1 | 0.85 |
| 3PPG – Punishment rate of unfair offers from human partners (%) | 50.7 | 35.5 | 57.5 | 39.2 | 44.3 | 30.7 | $1.97^{\dagger}$ |
| Average punishment rate of unfair offers across both games (%) | 46.9 | 28.4 | 51.6 | 29.7 | 42.6 | 26.7 | $1.71^{\dagger}$ |

$^{\dagger}p < .10$, $^{*}p < .05$, $^{**}p < .01$

**Behavioral Data**

I calculated the percentage of each offer type that was rejected or punished. I also calculated the average rejection rate of all unfair offers (average rejection rate of \$9:\$1, \$8:\$2, \$7:\$3) in the three games. Behavioral data are reported in Table 12 and in Figure 9. Using repeated measures analysis of variance, it was found that participants rejected unfair offers more than fair offers (\$5:\$5) in the Ultimatum Game with human partners ($F(1, 113) = 310.78$, $p < .001$), in the Ultimatum Game with computer partners ($F(1, 113) = 134.49$, $p < .001$), and in the Third Party Punishment Game with human partners ($F(1, 109) = 224.91$, $p < .001$). Paired samples t-test revealed that unfair offers in the Ultimatum Game were rejected more often when the partner was a human than when the partner was a computer, $t(113) = 6.94$, $p < .001$. In addition, unfair offers in the Third Party Punishment Game against human partners were punished more often than unfair offers in the Ultimatum Game against computer partners, $t(109) = 3.28$, $p < .002$. However, there was no difference in rejection/punishment rates for unfair offers in the Third Party Punishment Game against human partners and unfair offers in the Ultimatum Game against human partners, $t(109) = 1.02$, $p > .30$ (see Figure 9).

*Figure 9. Percentage of offers at each offer type that were rejected/punished in the Ultimatum Game (UG) and Third Party Punishment Game (3PPG), for human and computer partners.*



The correlations between rejection/punishment rates across the two games are presented in Table 13. As shown, there was reasonable stability in behavior, indicating that individuals who tended to reject unfair offers in the Ultimatum Game also tended to punish unfair offers in the Third Party Punishment Game.

*Table 13. Correlations between rejection rates in economic games*

| | UG-Human | UG-Computer |
|---|---|---|
| **Men and Women Combined** (n = 115, 54 men, 61 women) | | |
| UG-Computer | .74** | |
| 3PPG-Human | .62** | .38** |
| **Men Only (n = 54)** | | |
| UG-Computer | .65** | |
| 3PPG-Human | .73** | .45** |
| **Women Only (n = 56)** | | |
| UG-Computer | .81** | |
| 3PPG-Human | .51** | .28** |

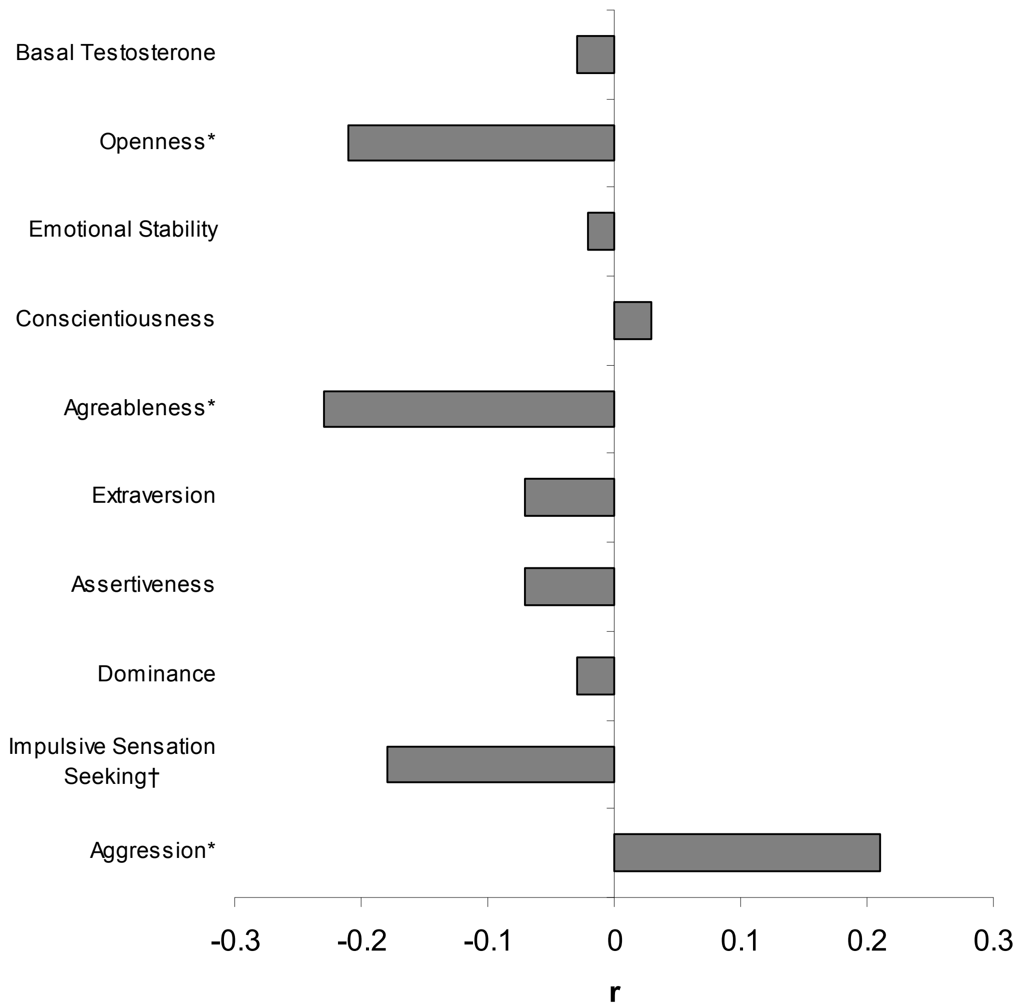
UG = Ultimatum Game, 3PPG = Third Party Punishment Game
$^{\dagger}p < .10$, $*p < .05$, $**p < .01$

**Predictors of Punishing Unfair Offers**

Because of the stability in behavior across the various games and the types of partners, I averaged across the human and computer trials and across the two games and calculated an overall percentage of punishing unfair offers (alpha = .87). Then I computed partial correlations between individual difference variables and punishment rates, controlling for participant sex. Sex was controlled for because there was a marginally significant sex difference in punishment rates such that men tended to punish unfair offers more often than women (see Table 12). For basal testosterone, the additional factor of time between wake up and the experiment was controlled for because basal testosterone levels were related to this variable, $r(114) = -.27$, $p < .01$. These partial correlations are presented in Figure 10.

As this figure shows, basal testosterone failed to predict punishment of unfair offers, but aggression was positively associated with punishment, whereas agreeableness and openness were negatively associated with rejection. Impulsive sensation-seeking was also negatively associated with rejection, but this effect was marginal, $p = .057$. Because aggression and agreeableness were highly correlated with one another, $r = -.64$, $p < .001$, we sought to determine whether they explained unique variance in punishment of unfair offers. When both terms were entered into a multiple regression along with participant sex, neither of these variables were statistically significant predictors of punishment (p's > .10), suggesting that aggression and agreeableness strongly overlap in predicting economic punishment.

*Figure 10. Partial correlations between individual difference variables and punishment of unfair offers, controlling for participant sex.*




†p< .10, * p < .05
Note: Basal testosterone correlation controls for time between wake up and the experiment as well as participant sex.

I next used a series of multiple regression models to test whether openness and impulsive sensation-seeking explained variance in punishment behavior above and beyond the aggression/agreeableness. These models are shown in Table 14.  Overall, these models seem to reveal that agreeableness/aggression are the best predictors of punishing unfair offers, followed by impulsive sensation seeking. Openness was no longer a significant predictor in these models.

*Table 14. Multiple Regressions Predicting Punishment of Unfair Offers*

| | Standardized Beta | t | p-value | R-squared |
|---|---|---|---|---|
| **Model 1** | | | | |
| 1. Participant Sex | -.17 | 1.86 | .07$^{\dagger}$ | |
| 2. Agreeableness | -.23 | 2.50 | .01* | |
| 3. Impulsive Sensation Seeking | -.19 | 2.09 | .04* | |
| Overall Model | | | .01** | .10 |
| **Model 2** | | | | |
| 1. Participant Sex | -.16 | 1.78 | .08$^{\dagger}$ | |
| 2. Agreeableness | -.17 | 1.85 | .07$^{\dagger}$ | |
| 3. Openness | -.15 | 1.56 | .12 | |
| Overall Model | | | .02* | .09 |
| **Model 3** | | | | |
| 1. Participant Sex | -.17 | 1.83 | .07$^{\dagger}$ | |
| 2. Agreeableness | -.21 | 2.17 | .03* | |
| 3. Openness | -.09 | 0.88 | .38 | |
| 4. Impulsive Sensation Seeking | -.16 | 1.64 | .10 | |
| Overall Model | | | .01** | .11 |
| **Model 4** | | | | |
| 1. Participant Sex | -.12 | 1.35 | .18 | |
| 2. Aggression | -.24 | 2.50 | .01* | |
| 3. Openness | -.11 | 1.15 | .25 | |
| 4. Impulsive Sensation Seeking | -.20 | 1.95 | .053$^{\dagger}$ | |
| Overall Model | | | .01** | .12 |

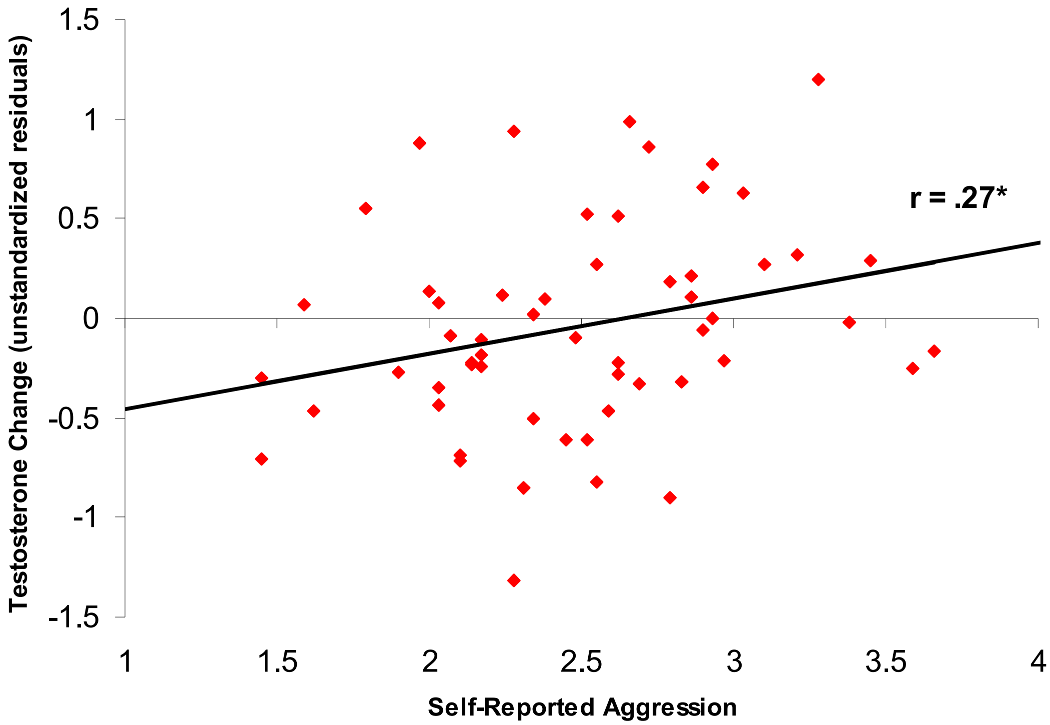
$^{\dagger}p < .10$, $^{*}p < .05$, $^{**}p < .01$

**Personality and Testosterone Fluctuations**

I next tested whether personality traits were associated with testosterone fluctuations in the study. A multiple regression was run with standardized time 2 testosterone as the dependent variable and the following variables as predictors: standardized time 1 testosterone, gender, aggression, and the gender x aggression interaction. The gender x aggression interaction was statistically significant, $t = 2.47$, $p < .05$, indicating that there were sex differences in the relationship between aggression and testosterone change.

To interpret this interaction, I first calculated testosterone change as the unstandardized residuals of a regression analysis with standardized time 1 testosterone as a predictor and standardized time 2 testosterone as the dependent variable. Then I conducted simple correlations between aggression and testosterone change in men and women separately. In men, aggression was unrelated to testosterone change, $r(52) = .02$, $p > .80$, but in women, there was a strong positive correlation between aggression and testosterone change, $r(58) = .44$, $p < .01$. Examination of the scatterplot revealed one outlier. When this outlier was removed, however, the correlation was still significant, $r(57) = .27$, $p < .05$. As shown in Figure 11, women high in aggression rose in testosterone throughout the study, whereas women low in aggression dropped in testosterone. I next tested whether other personality traits predicted testosterone changes. None of the other personality variables were statistically significant predictors of testosterone change, in men or in women, p's > .05.

*Figure 11.* *Relationship between self-reported aggression and testosterone change in women.*




**Testosterone Change and Economic Decisions**

Did changes in testosterone predict economic decisions above and beyond aggression in men or in women? In men, testosterone change was unrelated to economic decisions in any of the games, p's > .10. In women, testosterone change did not predict decisions in the Ultimatum Game (p's > .10), but there was a marginally significant positive correlation between women's testosterone change and punishing unfair offers in the Third Party Punishment Game, $r(54) = .25$, $p = .069$, indicating that women who rose in testosterone throughout the study were more likely to punish unfair offers in the Third Party Punishment Game. A multiple regression revealed that when controlling for aggression, testosterone change was still a marginally significant predictor ($p < .10$) of punishing of unfair offers for women playing the Third Party Punishment Game.

## Discussion

This study provides important evidence that personality traits predict economic decisions in the Ultimatum and Third Party Punishment Games. Aggression and disagreeableness were associated with a greater likelihood of punishing low offers across both games. This finding is important because scholars have generally explained punishment in these paradigms as a strategy to enforce fairness and social norms (e.g. Henrich et al., 2006). The results of the present study, however, suggest that economic punishment at a cost to oneself is a form of aggression. Based on this insight, future theory and research should continue to address the role that aggression plays in economic contexts.

This study also demonstrated that self-reported aggression predicted testosterone changes in women; high aggressive women rose in testosterone, whereas low aggressive women dropped in testosterone. This finding is important because it provides the first empirical link between aggression as a personality trait and testosterone fluctuations in humans. This finding is consistent with other research, which has shown that testosterone change in competition depends on a person's implicit power motive (Schultheiss et al., 2005). It also consistent with the larger animal and human literature that has connected testosterone to aggressive behaviors (Archer, 2006). What is surprising, however, is that this relationship emerged only in women, not in men. Most research on T and aggression has focused on men, although a small literature has connected T to aggressive behaviors in women (e.g., Dabbs & Hargrove, 1997). It is unclear why this sex difference emerged, but it does suggest that social endocrinology studies should incorporate women as well as men into the study of testosterone and social behavior.

According to the reciprocal model, fluctuations in testosterone should predict subsequent dominant behavior (Mazur & Booth, 1998; Mehta & Josephs, 2006). There was some support for this hypothesis. Women who rose in testosterone were more likely to punish low offers in the Third Party Punishment Game than women who dropped in testosterone, but this effect was only marginally significant. However, this study was not specifically designed to test the effects of testosterone change on behavior because the second saliva sample was taken at the end of the study. A follow-up study could be conducted in which participants play the Ultimatum Game, provide a second saliva sample 20 minutes after the game in order to measure the hormone response to this game (see Mehta & Josephs, 2006), and then play the Third Party Punishment Game. Such a study could provide more definite test as to whether testosterone changes predict subsequent decisions to punish low monetary offers.

One important limitation of this study was that cortisol levels were not measured. Studies 1 and 2 demonstrated interactions between testosterone and cortisol on implicit power (Study 1) and leadership behavior (Study 2). Thus, although basal testosterone failed to predict punishment of low offers in the present study, it is entirely possible that testosterone may interact with cortisol to predict economic punishment. Based on the results of Study 1 and Study 2, it could be the case that a combination of high testosterone coupled with low cortisol may predict a high rate of punishment, but low testosterone coupled with low cortisol may predict a lower rate of punishment. This hypothesis should be tested once the cortisol data are available.

# GENERAL DISCUSSION

The goal of this dissertation was to investigate how endocrine systems are associated with personality and social behavior. Specifically, I asked: Do testosterone and cortisol levels bear any relationship to personality traits and motives? Can these hormones predict leadership behaviors? What about social decisions? I incorporated diverse methodological approaches in an attempt to answer these questions, including the use of web-based questionnaires, salivary hormone measurement, and behavioral observation. My approach spanned the fields of social/personality psychology, neuroendocrinology, and behavioral economics. In taking such a broad approach, it was my goal to provide a strong empirical foundation that would motivate future inquiries in social endocrinology. In the following sections, I review some of the major findings and discuss their theoretical implications.

## Overview of findings

Table 15 includes the major findings across the four studies. Below I summarize each of the studies and its results.

Study 1 sought to identify the personality traits and implicit motives that are associated with basal testosterone and basal cortisol levels. In investigating this question, I took a multi-trait multi-method approach and collapsed across multiple samples in order to increase statistical power. One of the primary findings was that basal testosterone was negatively associated with conscientiousness in women. This effect was found using self-reports as well as informant reports of personality. There was also a positive relationship between basal testosterone and impulsive sensation-seeking in women. Finally, basal testosterone was positive related to masculinity and negatively related to femininity in both sexes, but basal testosterone failed to predict dominance, assertiveness, or aggression using self or informant reports.

*Table 15. Overview of major findings.*

| | **Outcome Measure (direction of relationship + or -)** | | |
|---|---|---|---|
| **Predictor** | **Men and Women** | **Men Only** | **Women only** |
| **1. Basal Testosterone** | *Masculinity (+)<br>*Femininity (-)<br>Competitive economic behavior (+) | | *Conscientiousness (-)<br>*Impulsive Sensation Seeking (+) |
| **2. Basal Cortisol** | *Extraversion (-) | Social Dominance Orientation (+) | |
| **3. Basal Testosterone x Basal Cortisol Interaction** | Implicit Power Motive<br>Leadership Behavior | | |
| **4. Aggression** | Economic punishment (+) | | Change in testosterone following economic conflict (+) |
| **5. Change in cortisol** | Competitive economic behavior (-) | | |

Note. * indicates that the finding replicates previous research. All other results have not yet been reported in the literature

Study 1 showed a negative relationship between basal cortisol and extraversion, indicating that low cortisol individuals are more likely to be extraverted than high cortisol individuals. Basal cortisol was positively associated with the Social Dominance Orientation, but this effect emerged in men only.

The last major finding from this study was that the interaction between basal testosterone and cortisol predicted variation in the implicit power motive. Individuals high in testosterone and low in cortisol were higher in power than individuals high in cortisol and high in testosterone. This was the first time this interaction has been shown.

Study 2 examined whether basal hormone levels could predict leadership behaviors (e.g., confidence, comfort, nervousness as leader) in leader-follower dyadic interactions. Neither basal testosterone nor basal cortisol predicted leadership on its own, but the interaction between these two hormones did. Specifically, high testosterone coupled with low cortisol was associated with good leadership, whereas low testosterone and low cortisol was associated with poorer leadership. The pattern was similar to the interaction found in Study 1. Although self-reported extraversion, dominance, and assertiveness were also related to leadership behavior, the testosterone-cortisol interaction predicted leadership above and beyond these self-reported personality traits.

Studies 3 and 4 extended this line of research to economic decision making in dyadic social interactions. Study 3 used an iterative two-player economic game (the Hawk-Dove game) and demonstrated that basal testosterone in interaction with the behavior of one's partner predicted economic decisions. When playing with a competitive player, both low and high testosterone individuals made competitive decisions. When playing with a cooperative player, however, high testosterone individuals behaved more competitively than low testosterone individuals. Change in cortisol was also related to economic decisions such that rises in cortisol predicted more cooperative decisions, whereas drops in cortisol predicted more competitive ones.

In Study 4, participants played two economic games (the Ultimatum and Third Party Punishment Games) in one-shot interactions with different partners. Self-reported aggression and agreeableness predicted decisions to accept or punish low monetary offers, such that high aggression was associated a greater frequency of punishment, whereas high agreeableness was associated with a lower frequency of punishment. Furthermore, self-reported aggression predicted fluctuations in testosterone over the course of the study, but only in women; high aggressive women increased in testosterone, whereas low aggressive women decreased. In the next section, I discuss some of the theoretical implications of these findings.

**TESTOSTERONE, PERSONALITY, AND SOCIAL BEHAVIOR: MOVING BEYOND AGGRESSION AND DOMINANCE**

The stereotype of a high testosterone individual is one who is masculine, aggressive, and socially dominant. Did the findings on hormones and personality provide evidence for this stereotype? Not really. Although high testosterone individuals were seen as more masculine and less feminine than low testosterone individuals, there was no compelling evidence that basal testosterone was related to stable individual differences in aggression or social dominance. These findings are consistent with the many null effects on testosterone and self-reported aggression/dominance that appear in the literature (cf. Mazur & Booth, 1998). Instead, high testosterone in the present research was related to lower conscientiousness and higher sensation-seeking, especially in women. The testosterone-conscientiousness finding replicates initial evidence from a previous study (Sellers et al., 2007), but the present research used a much larger sample and two different methods to assess personality: self and informant reports. These findings are also consistent with a growing body of evidence linking sex hormones to sensation-seeking, although most of this research has been conducted using measures of prenatal androgen exposure (2D:4D ratio; Fink et al., 2006), rather than circulating levels in adults. Even though testosterone failed to correlate with aggression and dominance as personality traits, testosterone was related to aggressive and dominant behaviors, such as competitive economic decisions in the Hawk-Dove game (Study 3). So what can explain these diverse and seemingly contradictory findings represented in the present research and in the larger literature?

One possibility is that testosterone may influence a larger biological system associated with low impulse control and sensation seeking (both of which have been linked to conscientiousness). This biological system might, in turn, play a more proximate role in the expression of aggression and social dominance. This idea is consistent with social psychological research, which has shown that impulsivity and sensation seeking influence aggressive behavior (Joireman, Anderson, & Strathman, 2003). One candidate neural system with which testosterone may interact is the orbitofrontal cortex (OFC), a brain region that has been previously linked to impulsive and aggressive behaviors as well as inhibitory and impulsivity-related processes (Coccaro et al., 2007b). From this perspective, rather than re-attempt to study testosterone-aggression or testosterone-social dominance relationships in isolation, a more fruitful next step for researchers would be to examine testosterone’s associations with facets of conscientiousness (impulsivity and sensation-seeking) and the biological systems that underlie them (e.g OFC).

#### CORTISOL, PERSONALITY, AND SOCIAL BEHAVIOR

Most neuroendocrinology research on cortisol has focused on its relation to psychological stress, immune function, and physical and mental health. Much less work, however, has examined how this hormone is related to social functioning. The findings from the present research suggest that cortisol does show meaningful and important relationships with personality and social behavior. One interesting finding was that basal cortisol was positively linked to social dominance orientation in men. The effect size of this relationship was quite strong relative to other hormone-personality relationships.

Indeed, this was the strongest correlation from the meta-analysis reported in Study 1. Individuals high in social dominance orientation endorse the existence of social hierarchies in society, and this belief system overlaps quite substantially with conservative political ideology (Jost & Sidanius, 2004). Even though political ideology was not directly measured in this research, the result from Study 1 leads to a highly provocative hypothesis -- that a neurobiological system of anxiety and psychological stress, of which basal cortisol is a part, may underlie conservative ideology in men. This hypothesis should be tested more rigorously in future research.

The present research also highlights the important role of hormone-hormone interactions on personality and social behavior. In two instances, neither testosterone nor cortisol alone was sufficient to predict personality or social behavior related to power and social dominance, but the interaction between the two hormones was. Specifically, the present research showed that the testosterone-cortisol interaction predicted the implicit power motive (Study 1) and leadership behavior (Study 2). The two interactions were remarkably similar to each other. Individuals with high testosterone and low cortisol showed high levels of implicit power motive in Study 1 and behaved in a more leader-like way in Study 2.

It has long been known that cortisol and testosterone interact in complex ways. Most of this research has focused on how chronic stress and high cortisol levels can lead to drops in testosterone (Sapolsky, 1985), with newer research showing a reciprocal effect – that basal testosterone in interaction with the social situation predicts fluctuations in cortisol (Mehta et al., under review). What is much less studied, however, is how basal testosterone and basal cortisol interact to predict a behavioral or personality outcome. To my knowledge, there have only been two studies that have reported an interaction between basal testosterone and basal cortisol, and both showed its relationship to aggression (Dabbs et al., 1991; Popma et al., 2007). Thus, the two findings from the present research are only the third and fourth ones demonstrating that the testosterone-cortisol interaction predicts personality and social behavior. This interaction is consistent with idea that high testosterone may underlie impulsivity and sensation-seeking (Study 1), whereas low cortisol may serve as a behavioral disinhibitor (Study 1), together which produces power-related personality traits and social behavior. Although it is still unclear what the exact neural mechanism underlying this interaction is, it is quite clear that future research should continue to measure testosterone and cortisol simultaneously and investigate how they interact to influence psychological outcomes.

## The Future of Social Endocrinology

The present research made substantial progress in demonstrating associations between hormones, personality, and behavior, but there are still many unanswered questions. In this last section, I outline some important directions for future research in social endocrinology.

### Causality

Do hormones cause variation in personality and social behavior? In all of the studies reported in this dissertation, *endogenous* hormones were measured, and thus, causality cannot be known. To test for causality, additional studies must be conducted in which hormones are exogenously administrated or suppressed. Such studies have already begun to emerge in the human behavioral sciences, with techniques such as oxytocin administration via nasal spray (Kosfield et al., 2005) and testosterone administration via sublingual injection (van Honk et al., 2001). Future research should continue to take advantage of these methods.

Another important approach to determine causality is through comparative research in animals. Indeed, many experimental approaches that are not feasible in humans can be conducted in animals (Mehta & Gosling, 2006). One type of animal study that can greatly contribute to research in social endocrinology is basal hormone manipulation (e.g., Viau & Meaney, 1996). Manipulating basal testosterone, for example, requires removal of the gonads and subsequent implantation, which is not possible in humans. Animal studies that manipulate basal testosterone as well as basal cortisol could test whether their interaction has a causal influence on aggression. If such studies did indeed show causal effects, they would suggest that this interaction plays a causal role in explaining aggression in humans.

**Circadian rhythms**

Do hormone-behavior relationships depend on the time of day? In the Leader-Follower sample, only one hormone sample was taken. In the other two samples, multiple samples were taken, but they were taken around the same time of day. It is well-known that there are circadian fluctuations in hormone levels, such that levels of testosterone and cortisol are highest in the morning, drop throughout the day, and rise again in the evening. However, the present research was largely confined to afternoon samples, and did not attempt to capture people's circadian rhythms. Ideally, hormone levels would be measured at multiple times throughout the day in order to determine whether morning, afternoon, or evening hormone levels are the best predictors of personality and social behavior. There is also the possibility that changes in hormone levels throughout the day, independent of absolute levels, are related to personality traits (e.g., Sakaguchi et al., 2006). Circadian studies of hormones can be logistically challenging, but must be conducted in order to fully understand the nature of hormone-behavior relationships.

**Sex similarities and differences**

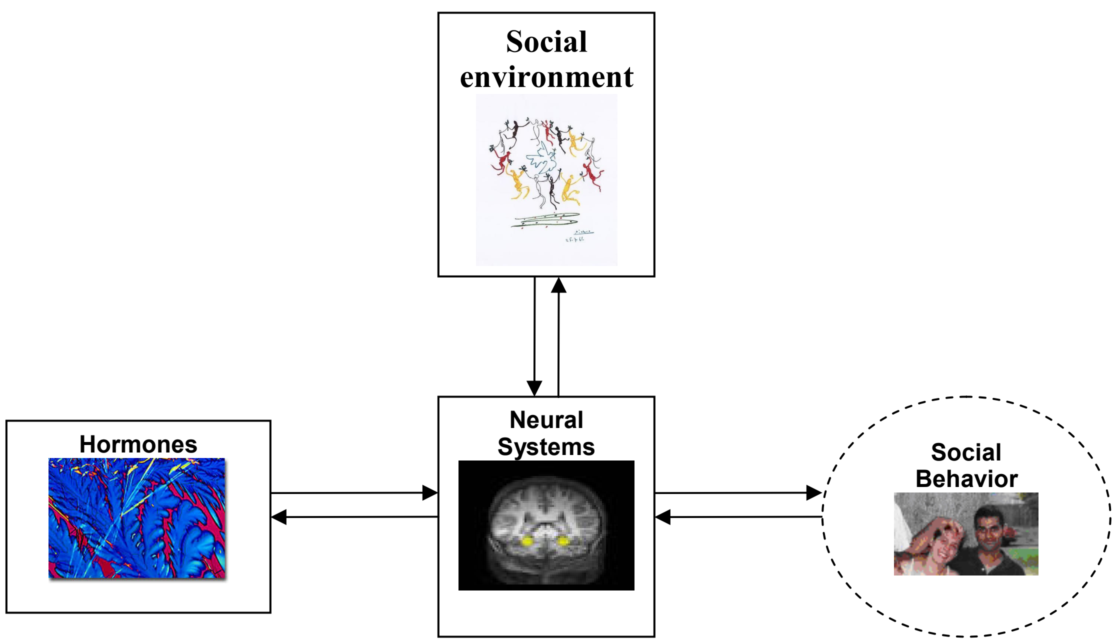
Are there sex differences in the effects of hormones on social behavior? The literature on testosterone and its behavioral correlates has focused primarily on men, with much less attention devoted to women. The present studies included both sexes and found that there were sex differences in some studies (e.g., the basal cortisol-social dominance orientation relationship in men, but not in women), but similarities across the sexes in others (e.g., testosterone-cortisol interaction as a predictor of leadership across men and women). However, it is not clear what biological mechanisms drive these differences. As more findings are accumulated in men as well as women, theoretical models must be devised to explain when sex differences will emerge, and when they will not.

**Hormone-Brain Relationships**

What are the neural pathways through which hormones influence behavior? The study of hormone-behavior relationships can be fruitful on their own, but such studies cannot fully explain behavior because endocrine systems do not directly influence behavioral outcomes. By incorporating measures of hormones, neural systems, and the social environment in the same research program, researchers can test more complex theoretical models (e.g., mediation, moderation) in order to better understand the biological pathways that lead to the expression of social behaviors (see Hariri et al., 2006 for models of gene-neural systems-behavior pathways). As shown in Figure 12 for example, neural systems necessarily mediate the effects of hormones on behavior.

Therefore, research that examines the effects of hormones on neural systems, and in turn, the effects of these neural systems on behavior may yield important insights about the complex biological processes underlying behavior. Although hormone-brain relationships have been studied extensively in animals, very few studies have examined these relationships in humans. Future research in social endocrinology can conduct such studies in humans by combining hormone measurement with technologies such as functional magnetic resonance imaging.

*Figure 12. Theoretical model of relationships among hormones, neural systems, the social environment, and social behavior.*




**CONCLUSION**

Why do people do the things they do? Without a doubt, the answer lies in the complex biological systems that make up who we are. The challenge for researchers is how to come to understand these systems. Social and personality psychology has by and large neglected the biological level analysis, but the four studies presented in this dissertation showed that one class of biological variables – hormones -- can provide unique insights into social functioning. Testosterone, cortisol, and their interaction were all associated with diverse facets of personality and social behaviors, ranging from leadership behavior to economic decisions. The field of social endocrinology is only in its infancy, but it has the potential to make enormous contributions to many areas of psychology-- especially to research on the biological systems of personality and social behavior.

## Appendix A: Informant Report Questionnaire

| Item | Construct |
|---|---|
| 1. Is extraverted, enthusiastic. | Extraversion (E) |
| 2. Is critical, quarrelsome. | Agreeableness (A) |
| 3. Is dependable, self-disciplined. | Conscientious (C) |
| 4. Is anxious, easily upset. | Neuroticisms (N) |
| 5. Is open to new experiences, complex. | Openness (O) |
| 6. Is reserved, quiet. | E |
| 7. Is sympathetic, warm. | A |
| 8. Is disorganized, careless. | C |
| 9. Is calm, emotionally stable. | N |
| 10. Is conventional, uncreative | O |
| 11. Is hard-working | Achievement (Ach) |
| 12. Is friendly, warm towards others. | Affiliation (Aff) |
| 13. Tries to influence others to get what he/she wants | Dominance (Dom) |
| 14. Is competitive | Dom/Power (Pow) |
| 15. Is a good leader. | Leadership (L) |
| 16. Is rebellious | Psychopathy (Psych) |
| 17. Is honest | Machiavell. (Mach) |
| 18. Values money | Financial Motiv(FM) |
| 19. Strives to be the best in his/her chosen field. | Ach |
| 20. Spends a lot of time with his/her friends | Aff |
| 21. Is power-oriented | Dom/Power (Pow) |
| 22. Tries to impress others | Narcissism (Nar) |
| 23. Makes decisions quickly and efficiently. | L/Assertiveness (Ass) |
| 24. Is feminine. | Femininity |
| 25. Usually lets others do the talking in groups. | Ass |
| 26. Is cunning | Psych |
| 27. Cares about being successful | Ach |
| 28. Often prefers to spend time alone than with others. | Aff |
| 29. Is dominant, forceful, and assertive. | Ass |
| 30. Enjoys taking risks. | Psych/Risk-Taking |
| 31. Is moral, ethical | Mach |
| 32. Set high standards of achievement for himself/herself. | Ach |
| 33. Cooperates with others. | Aff |
| 34. Is controlling | Dom/Pow |
| 35. Overestimates his/her abilities | Nar |
| 36. Does NOT enjoy gambling for serious money. | Risk-Taking |
| 37. Is bossy | Dom/Pow |
| 38. Is often the leader of groups to which he/she belongs | Ass/L |
| 39. Is argumentative | Dom/Pow |
| 40. Has high self-esteem | Self-esteem |

| | |
|---|---|
| 41. Is arrogant | Nar |
| 42. Is intelligent | Intelligence |
| 43. Always wants to be the center of attention | Nar |
| 44. Is physically attractive | Phys. Attr |
| 45. Tends to brag | Nar |
| 46. Is likeable | Likeability |
| 47. Thinks too much of him/herself | Nar |
| 48. Is athletic. | Athleticism |
| 49. Gets hostile when challenged | Aggressiveness (Agg) |
| 50. Is depressed. | Depression (D) |
| 51. Can't take criticism | Nar |
| 52. Is religious. | Religiosity |
| 53. Takes charge of a situation. | Ass |
| 54. Is trusting of others | Mach |
| 55. Is masculine. | Masculinity |
| 56. Often seeks out excitement. | Sensation-Seeking |
| 57. Is often rude to others. | Psych |
| 58. Gets bored easily. | Sensation-Seeking |
| 59. Cares about his/her financial well-being | FM |
| 60. Tends to dominate group discussions | Pow/Dom/Ass |
| 61. Is confident when directing the activities of others | Dom/Pow |
| 62. Is effective in getting others to agree with him/her | Dom/Pow |
| 63. Is satisfied with life. | Life Satisfaction |
| 64. Is deceitful | Mach |
| 65. Feels uneasy when he/she has to tell people what to do. | Ass/Pow/Dom |
| 66. Is aggressive | Agg |
| 67. Tends to play it safe. | Risk-Taking |
| 68. Sucks up to authority figures | Dom |
| 69. Other people often look to X to make decisions. | Ass |
| 70. Remains calm in tense situations | Anxiety |
| 71. Tends to do what other people do | Agreeableness |
| 72. Is happy | Happiness |
| 73. Is nervous | Anxiety |
| 74. Is hostile | Agg |
| 75. Is excited | Positive Affect |
| 76. How would you characterize X's political views? | Political Orientation |

## Appendix B1: Hormone and Personality Correlations in the Leader-Follower Sample

| Self-Reported Personality Trait | Men and Women (n = 176) | | Men (n = 85) | | Women (n = 91) | |
|---|---|---|---|---|---|---|
| | T[a] | Cort[b] | T[a] | Cort[b] | T[a] | Cort[b] |
| 1. Extraversion | .05 | -.10 | .09 | -.03 | -.00 | -.16 |
| 2. Agreeableness | .09 | .10 | .16 | .13 | -.00 | .08 |
| 3. Conscientiousness | -.15[†] | -.00 | -.13 | -.12 | -.18 | .08 |
| 4. Emotional Stability | .04 | -.02 | -.11 | -.18 | .17 | .09 |
| 5. Openness | -.04 | -.08 | -.09 | -.05 | -.03 | -.11 |
| 6. Assertiveness | .06 | -.03 | -.00 | -.06 | .13 | .00 |
| 7. Dominance | .03 | -.03 | .05 | -.04 | .02 | -.03 |
| 8. Social Dominance Orientation | .02 | .08 | .12 | .31** | -.05 | -.09 |

[†] $p < .10$, * $p < .05$, ** $p < .01$, T = Testosterone. Cort = Cortisol.

a. Partial correlations between basal testosterone (z-scores, standardized within sex) and personality traits, controlling for time of day.
b. Partial correlations between log-transformed basal cortisol and personality traits, controlling for time of day

## Appendix B2: Hormone and Personality Correlations in the Hawk-Dove Sample

| **Self-Reported Personality Trait** | **Men and Women (n = 98)** | | **Men (n = 41)** | | **Women (n = 55)** | |
|---|---|---|---|---|---|---|
| | T[a] | Cort[b] | T[a] | Cort[b] | T[a] | Cort[b] |
| 1. Extraversion | -.03 | -.16 | .15 | -.21 | -.16 | -.05 |
| 2. Agreeableness | .00 | .03 | -.01 | .11 | .02 | .04 |
| 3. Conscientiousness | .05 | -.09 | .02 | -.15 | .11 | -.12 |
| 4. Emotional Stability | .00 | .10 | -.17 | .17 | .03 | -.03 |
| 5. Openness | -.04 | -.00 | .09 | -.05 | -.26† | .13 |
| 6. Assertiveness | .01 | -.17† | .06 | -.23 | -.01 | -.17 |
| 7. Dominance | .02 | .02 | .09 | -.02 | .02 | -.06 |
| 8. Social Dominance Orientation | .00 | .14 | .01 | .12 | -.01 | .08 |

†$p < .10$, *$p < .05$, **$p < .01$, T = Testosterone. Cort = Cortisol.

a. Partial correlations between basal testosterone (z-scores, standardized within sex) and personality traits, controlling for time of day.
b. Partial correlations between log-transformed basal cortisol and personality traits, controlling for time of day

## Appendix B3: Hormone and Personality Correlations in the Ultimatum/Third Party Punishment Sample

| Self-Reported Personality Trait | Men and Women (n = 115) | | Men (n = 54) | | Women (n = 61) | |
|---|---|---|---|---|---|---|
| | $T^a$ | $Cort^b$ | $T^a$ | $Cort^b$ | $T^a$ | $Cort^b$ |
| 1. Extraversion | -.15 | -- | -.08 | -- | -.21 | -- |
| 2. Agreeableness | -.05 | -- | -.04 | -- | -.04 | -- |
| 3. Conscientiousness | -.14 | -- | .11 | -- | -.37* | -- |
| 4. Emotional Stability | -.03 | -- | -.07 | -- | .05 | -- |
| 5. Openness | -.04 | -- | -.05 | -- | -.04 | -- |
| 6. Assertiveness | -.17$^{\dagger}$ | -- | -.23 | -- | -.11 | -- |
| 7. Dominance | -.11 | -- | -.09 | -- | -.13 | -- |

$^{\dagger}p < .10$, $^{*}p < .05$, $^{**}p < .01$, T = Testosterone. Cort = Cortisol.

a. Partial correlations between basal testosterone (z-scores, standardized within sex) and personality traits, controlling for time of day.
b. Cortisol levels were not available for this sample.

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